TECHNIQUES AND PROCEDURES

OF

ANESTHESIA

Second Edition

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By

JOHN ADRIANI, M.D.

Director, Department of Anesthesiology, Charity Hospital
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INTRODUCTION

The technique of anesthesia cannot be learned from books. For the most part, the instruction must be practical and can only be taught in the operating room. However, this practical instruction should be supplemented by organized lectures or classroom work.

The author has found that an outline of procedures based upon the fundamentals of anesthesia simplifies and expedites the process of teaching and learning for both instructor and pupil. This outline of procedures and techniques has been employed by the author as a guide for beginners in anesthesia.

It is obvious that an author cannot assemble a book of procedures which would please and satisfy every anesthetist who is engaged in teaching anesthesia. *The material which must be compressed into an outline of this sort is vast.* Adequate condensation is not possible without slighting topics and details which, to some teachers, may appear more important than the topics and details outlined.

Each anesthetist ultimately develops his own technique and manner of performing his duties. It would appear, then, that almost as many individual techniques exist for a given procedure as there are anesthetists. However, closer scrutiny will reveal that these seemingly varied techniques are all based upon the same fundamental principles and that they differ from one another only in minor details.

The techniques described in this book are those which illustrate fundamental principles and which the author has found adaptable for student personnel and suitable in his management of the Department of Anesthesia at Charity Hospital of Louisiana at New Orleans.

The author lays no claim to originality of any of the techniques outlined. Many have been employed for so long a period of time that they are now accepted medical practice. Others have been introduced recently and are described with modifications. Reference is made to the original description of a technique or procedure and its author, whenever this is possible, and particularly in the case of newer techniques. The methods of regional anesthesia are based upon the approaches advocated by Labat and his teachers and pupils.

The author wishes to stress the fact that there is no such thing as a "routine" in the administration of anesthetics. Each situation and each patient which the student encounters presents a different problem. No two situations are identical. Each step in the performance of one's duties has an underlying reason behind its execution. The reason may be a physiologic, pharmacologic or other equally important fact. An attempt has been made in this outline not only *to enumerate the technical details* of anesthesia but *the associated reasons for executing them* in the manner described.

The conduct of anesthesia is influenced by such variable factors as the disease with which the patient is afflicted, the type of operation to be performed, the skill and dexterity of the surgeon, or the pharmacologic effect of the drug upon the patient In order to be a skillful technician, the anesthetist must possess a knowledge of the fundamental sciences, diagnostic acumen, and that faculty which, in medicine, is known as judgment The student will do well, if he wishes to balance his training, to pursue parallel reading in the fundamental sciences of anatomy, chemistry, physiology, pharmacology, pathology, and in clinical subjects related to the field of anesthesiology

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J A

New Orleans

PREFACE TO SECOND EDITION

A dozen years have elapsed since the material for the first edition of this book was assembled During that time there have been numerous refinements and innovations in anesthesia New drugs have been introduced requiring new techniques or modification of old techniques Some of these did not stand the test of even a few years time and are no longer used Others have proved useful and are with us yet The more important of these advances and uses of new drugs have been included in this edition It is hoped that this edition will continue to be as useful as the first has proved to be as evidenced by the continued demand for the volume during the past decade

The writer is grateful to Dr Meyer Saklad, to Dr C R Stephen, and to Dr Robert Hosler for the use of illustrations from their respective books, *Inhalation Therapy, Elements of Pediatric Anesthesia*, and *Cardiac Resuscitation*, and to Dr Donovan Campbell and Dr Roger Witt for assistance in proofreading

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TECHNIQUES AND PROCEDURES
OF
ANESTHESIA

PART I

GENERAL CONSIDERATIONS

TYPES OF ANESTHESIA

The types of anesthesia may be classified according to the routes of administration of drugs employed

The following types are available

1 *Inhalation* Narcosis is produced by inhalation of gases or vapors of highly volatile liquids
2 *Regional* Anesthesia is obtained by applying a drug along the course of a nerve Sensation is abolished by one of the following methods
   a Spinal anesthesia The drug is applied to the anterior and posterior roots and sympathetic fibers of the nerve as it passes from the spinal cord through the subarachnoid space
   b Epidural anesthesia The drug is applied to the nerve as it passes from the dura but while it is still in the canal of the vertebral column
   c Nerve block The drug is applied at some point along the course of the nerve before it divides into its terminal branches
   d Topical, field block, and infiltration The drug is applied at the nerve endings (Physical agents such as pressure and cold may be applied to nerve endings to produce anesthesia also)
3 *Intravascular* Narcosis is obtained by injecting an aqueous solution of a drug directly into the blood stream as follows
   a By intravenous injection
   b By intra arterial injection
   c By intramedullary injection (marrow puncture)
4 *Rectal* Narcosis is obtained by administering an aqueous or oily solution of a drug as an enema
5 *Intraperitoneal*. Narcosis is obtained by injecting an aqueous solution of a drug into the peritoneal cavity The drug is absorbed into the systemic circulation from the serous surface This technique is limited chiefly to animals
6 *Oral* Narcosis is obtained by ingestion of solutions of drugs or the pure drugs so that they are absorbed through the upper portion of the gastro intestinal tract
7 *Subcutaneous and Intramuscular* Narcosis is obtained by injecting aqueous or oily solutions of soluble drugs into these tissues

Available Drugs

Drugs used for anesthesia are central nervous system depressants Two types are recognized—the volatile and non volatile

Volatile drugs are gases or liquids with low boiling points The currently used gases are nitrous oxide, ethylene and cyclopropane The currently used liquids are *ether*, *vinethene*, *chloroform*, *ethyl chloride* and *trichlorethylene*

The non-volatile drugs are solids or liquids with vapor pressures too low to be effective at room temperature Currently used drugs are *avertin*, *chloral*, *paraldehyde*, *pentothal*, *evipal*, *surital*, *the narcotics*, *morphine*, *dilaudid demerol*, *methadon*, *nisentil* and *dromoran*

The local anesthetics are non-volatile substances also The currently used drugs are described in Part VI

Combinations of Drugs and Routes

In present day anesthesia practice, combinations of drugs and routes are used Some of the currently employed combinations are as follows

1 Inhalation plus basal narcosis induced by injecting a non-volatile drug intravenously, intramuscularly or rectally Example nitrous oxide oxygen plus pentothal intravenously
2 Inhalation plus basal narcosis plus a muscle relaxant Example nitrous oxide oxygen plus pentothal plus curare
3 Regional plus inhalation Example spinal block plus cyclopropane
4 Regional plus basal narcosis induced by injecting a non-volatile drug intravenously, intramuscularly or rectally Example spinal block plus pentothal

GENERAL DUTIES OF THE ANESTHETIST

Duties	*Reasons*
1 The anesthetist should visit the patient in advance of operation in order to evaluate the patient as an operative risk and to decide upon premedication, type, and techniques of administration of anesthesia	Familiarity with the patient's abnormalities is necessary in order to avoid the many pitfalls of anesthesia
2 **The anesthetist should assemble all the necessary equipment and be prepared to induce anesthesia at least 15 minutes before the scheduled time of operation**	Induction of anesthesia may be prolonged as a result of technical difficulties, slow action of drugs or other allowable delays, thus interfering with the progress of the surgical team
3 The anesthetist should verify the	In large institutions confusion may

TABLE I

General Properties and Characteristics of Currently Employed Anesthetic Drugs

Name	Chemical Name	Formula	Description	B P or M P	S G	Stability	Preservative	Packaged	Accepted	Remarks
Ether	Diethyl oxide	$C_2H_5-O-C_2H_5$	Colorless mobile inflammable liquid with pungent odor	B P 36–37 C	Liq 718 at 15 C Vap 2 6	Oxidized by air or oxygen light or heat to peroxides	Copper or iron	Dark bottles cans	U S P	Contains up to 4% alcohol from manufacturing process
Vinethene	Vinyl oxide	$C_2H_3-O-C_2H_3$	Colorless inflammable liquid with garlic like odor	B P 28 29 C	Liq 77 at 20° C Vap 2 2	Polymerizes to resins Decomposed by acids	Basic substances, amines or other	Dark bottles	U S P	Contains 4% added alcohol to elevate boiling point.
Chloroform	Trichlor methane	$CHCl_3$	Sweet pungent liquid yielding heavy vapor	B P 60–61 C	Vap 4 12	Oxidized by air oxygen light or heat	Ethyl alcohol	Dark bottles	U.S.P	Contains added alcohol to act as a preservative
Ethyl chloride	Monochlor ethane	C_2H_5Cl	Colorless mobile highly volatile liquid	B P 12 5–15 C	Liq 921 at 20 C Vap 2 28	Hydrolized to alcohol and hydrochloric acid	None added	Dark glass or metal amploa	U.S P	Contains alcohol from manufacturing process.
Trilene	Trichlor ethylene	C_2HCl_3	Sweet pungent mobile liquid	B P –8 C		Oxidized by air oxygen light heat and soda lime	Thymol	Dark bottles	U S P	
Paraldehyde	Polymer of acetaldehyde	$(CH_3CHO)_3$	Colorless mobile liquid with pungent clinging odor	B P 121–122 C	Liq 999 at 20 C	Converted to acetaldehyde Very slowly decomposed by acids	None added	Dark bottles.	U.S P	May contain traces of acetaldehyde
Amylene hydrate	Tertiary amyl alcohol	$C_5H_{11}-OH$	Colorless mobile liquid	B P 98–100 C		Stable	None added	Dark bottles.	U S P	Used as solvent for tribromethanol to form avertin.
Trichlor ethanol	1 Hydroxy 2 Trichlor ethane	CCl_3CH_2OH	Colorless liquid	B P 151 C at 751 mm Hg	Liq 1 555 at 20 C	Oxidized to aldehydes and hydrobromic acid Decomposed by heat light, air	Keep cool away from light	Dark bottles.		Sparingly soluble in water but will make a 3% solution at 37° C
Tribrom ethanol	1 Hydroxy 2 Tribrom ethane	CBr_3CH_2OH	White powder, which sublimes with decomposition	M P 80 C		Oxidizes to aldehydes and acids decomposed by heat light air	Keep cool away from light heat air	Dark bottles.	U S P	1 gram dissolves in ½ cc of amylene hydrate to form 1 cc of avertin fluid.
Ethylene	Ethene	C_2H_4	Colorless gas with an ethereal odor	B P 103 C	Vap 97	Stable at ordinary conditions	None added keep in a cool place	Compressed into a liquid and stored in steel cylinders	U S P	Carbon monoxide a possible impurity
Cyclopropane	Trimethylene	C_3H_6	Colorless sweet smelling gas	B P –34 C	Vap 1 46	Stable at ordinary temperatures and pressures	None added keep in cool place	Compressed into a liquid and stored in light metal cylinders	U S P	A polymer of propylene in presence of iron at 100° C may be converted to propylene.
Nitrous oxide	Nitrogen monoxide	N_2O	Colorless sweet smelling gas	B P –89 C	Vap 1 54	Stable	None added keep in cool place	Compressed into a liquid and stored in heavy metal cylinders	U S P	Noninflammable but supports combustion

nature of the contemplated operation and name of the patient with the patient himself before anesthesia is induced	occur and the wrong patient may be operated upon or the wrong operation may be attempted
4 The anesthetist should verify the patient's age and note whether or not permission for operation on the patient's chart has been signed	Minor females and males (under 21 years) may not sign for consent for operation (In some states married males and females may sign consent even though not of age)
5 **The anesthetist should have the patient under continued surveillance from the moment of induction of anesthesia until he is returned to bed**	The anesthetist is responsible for the patient so long as it is dangerous to entrust him to less experienced individuals who may care for him in the post anesthetic period
6 The anesthetist should maintain an accurate and complete record of the entire procedure and note all events as they occur	Records are essential for many reasons (1) As future references in the event of complications, (2) for case analysis, (3) as an aid to prognostication during surgery, (4) for a source of statistical data (punch card), and (5) for medicolegal purposes

SELECTION OF ANESTHESIA

No rule can be formulated regarding selection of anesthesia

The following variable factors should be considered in each individual case

1 The type and duration of operation to be performed, and the depth of anesthesia required to complete it
2 The physical state of the patient
3 The skill and dexterity of the surgeon and the degree of muscle relaxation demanded by the surgeon
4 The skill of the anesthetist
5 The pharmacological action of drugs in question and their relationship to the underlying disease

TABLE II

Selection of Anesthesia in the Order of Their Greatest Desirability, Most Usefulness or Least Objectionable Features

Problems Encountered	*Choices*	*Remarks*
	Head	
1 Skull—Intracranial Operations—Craniotomy, Lobotomy, Plastics on Cranium		
Clinical 1 May be comatose, irrational, psychotic, uncooperative, dehydrated, emaciated 2 May have respiratory failure requiring artificial respiration throughout operation 3 May have expanding lesions, infections, hemorrhage, trauma, all leading to increased intracranial pressure	1 Local 2 Pentothal or avertin basal, nitrous oxide intratracheally, with topical 3 Nitrous oxide—ether oxygen sequence	Most suitable for most operations Most desirable from standpoint of flammability in noncooperative patients Most suitable but flammable. Use justified only when others are contraindicated
Surgical 1 May be unusually long 2 Use high frequency current (explosion hazard) 3 Excessive bleeding may be encountered (neoplasms) 4 Are done *in prone or other awkward* positions. Requires endotracheal tube 5 Scalp highly vascular (add epinephrine with local) 6 No relaxation necessary 7 May need to be awake in certain operations (for stimulation of cortical areas) 8 Bone difficult to anesthetize with local anesthesia	*Less Desirable or Contra Indicated* 4 Ethylene or cyclopropane 5 Pentothal alone 6 Avertin alone or with local	 Flammable Airway not under control. Excessive quantity required Airway not under control. Operation outlasts narcosis
Anesthetic 1 Coughing or straining raises intracranial pressure 2 Projectile vomiting may occur, increasing possibility of aspiration 3 CO_2 excess or anoxia to be avoided. Raise intracranial pressure 4 Anesthetist must be away from operative field. Intratracheal tube required 5 Reflex changes may cause circulatory and respiratory disturbance		
2 Skull—Ventriculogram		
Clinical 1 May be comatose, irrational, psychotic, uncooperative, dehydrated, emaciated 2 May have respiratory failure requiring constant artificial respiration	1 Local 2 Nitrous oxide intratracheally with topical and basal of pentothal 3 Nitrous oxide—ether oxygen sequence intratracheally 4 Cyclopropane and oxygen	Suitable when rational Suitable when electro surgical unit is used Flammable. Used when nonvolatile drugs are not desired *CO_2 retention may raise intra*cranial pressure. Flammable
Surgical 1 Short duration 2 No relaxation needed 3 Done in semi upright or sitting position 4 Respiratory failure may be present or may occur	*Not Desirable or Contraindicated* Any of the above without an intratracheal airway	
Anesthetic 1 Must remain anesthetized until X Rays are taken	*Children* 1 1 or 2 2 Local	 Suitable if cooperative

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
3 Skull—Encephalogram		
Clinical		
1 May be comatose irrational psychotic uncooperative dehydrated emaciated	1 Local with sedation	Suitable for cooperative subjects who are not comatose
Surgical	2 Pentothal basal intravenously and nitrous oxide	Non inflammable most practical
1 Usually performed in sitting position	3 Pentothal basal alone	Large amounts of barbiturate often required
2 Usually brief	4 Open drop ether	Suitable for children
3 May cause shock or respiratory failure	5 Avertin alone	Respond to pain induced by air injection and struggle
Anesthetic		
1 Airway not easily maintained		
2 Must remain narcotized until X Rays are taken		
3 Fire hazard present due to X Ray unit		
4 Respiratory failure secondary to neurological disease may occur		
4 Skull—Extracranial Operations—Plastic Operation Removal of Cyst etc		
Clinical		
1 Patients usually in good condition	1 Local	Most suitable
2 Intracranial pressure rarely affected	2 Cyclopropane intratracheally	Labile rapid acting
Surgical	3 Nitrous oxide or ethylene with ether intratracheally	When 1 and 2 are not desired
1 May be minor and brief	4 Nitrous oxide intratracheally topical and pentothal basal	When fire hazard exists
2 Scalp highly vascular (add epinephrine with local)		
3 Relaxation not needed		
Anesthetic	*Less Desirable or Contraindicated*	
1 Anesthetist must be out of operative field	5 Anesthetics listed above with no intratracheal airway	Airway not under control
2 May be done in prone position	6 Pentothal alone	Excess drug needed Airway not under control
3 Bone difficult to anesthetize with local anesthesia	7 Avertin alone	Same as 6
	Children	
	1 Cyclopropane intratracheally	
	2 Ether intratracheally	
	3 Nitrous oxide intratracheally with basal of avertin or pentothal	
5 Eye—Evisceration Plastic on Lids Retinal Operations Removal of Tumors Muscle Transplants Removal of Cataracts Lens Transplants Relief of Glaucoma, etc.		
Clinical		
1 Many are very young or in upper age groups	1 Local	Best suited for adults
2 Glaucoma may be present—Avoid atropine	2 Cyclopropane intratracheally and muscle relaxant	Nausea may occur
Surgical	3 Pentothal nitrous oxide intratracheally muscle relaxant	Prolonged depression postoperatively—nausea minimal
1 Eyeball must be fixed—deeper anesthesia required	*Less Desirable*	
2 Nausea vomiting in postoperative period must be avoided	4 Ether intratracheally	Nausea and vomiting frequent
Anesthetic	5 Local and muscle relaxant	Airway not under control
1 Anesthetist must be away from operative field Endotracheal tube required to control airway	6 Ether insufflation	Not advised Airway not under control
2 Coughing and sneezing impair surgical result	*Children*	
	1 Cyclopropane or ether intratracheally	
3 Head and face covered by drapes	2 Insufflation ether	Ordinarily used Not advised Airway not under control

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
6 Face—Plastic Surgery Reduction of Fractures Excisions of Moles or Scars Incisions and Drainage		
Surgical 1 Areas may be highly vascular 2 Relaxation not needed 3 May be lengthy 4 Electrosurgical unit may be used *Anesthetic* 1 Anesthetist must be away from operative field Intratracheal tube needed	1 Block of branches of 5th Nerve	Not always satisfactory and of sufficient duration
	2 Cyclopropane intratracheally	Most desirable
	3 Pentothal basal nitrous oxide intratracheally with topical	Suitable for short procedures or when electrical equipment is used
	4 Ether intratracheally preceded by nitrous oxide or ethylene	Used when 1 and 2 are contra indicated
	5 Local infiltration	In simple brief procedures
	Children	
	1 Cyclopropane intratracheally	Most desirable because of lability and rapidity of action
	2 Ether intratracheally	
	3 Pentothal basal nitrous oxide intratracheally	
7 Ear—Mastoidectomy		
Clinical 1 May have acute infection 2 Sepsis fever etc. may be present 3 May have signs of meningeal irritation or increased intracranial pressure 4 Acute in children most often—chronic in adults 5 In children more often than adults *Surgical* 1 May be long and tedious 2 No relaxation needed 3 Surgeon may use epinephrine in wound 4 Surgeon may use dental drill with electric motor 5 Room may be darkened *Anesthetic* 1 Airway not under control unless tube is used 2 Head turned to one side and covered by drapes	1 Cyclopropane intratracheally	Labile—rapid recovery
	2 Nitrous oxide and pentothal basal	*Used when fire hazard is present.*
	3 Nitrous oxide or ethylene followed by ether	When 1 and 2 cannot be used
	Less Desirable or Not Suitable	
	4 Local	
	Children	
	1 Cyclopropane intratracheally	When respiratory infection is present
	2 *Pentothal basal nitrous* oxide	*When fire hazard is present*
	3 Nitrous oxide-ether intratracheally	
	4 Ether open drop followed by insufflation	Usual method employed but does not permit control of airway
8 Ear—Myringotomy		
Surgical 1 Brief requiring a few minutes 2 Airway not difficult to control for such a brief period 3 Room may be darkened *Clinical* 1 Usually in children	1 Cyclopropane	Use if intratracheal tube is necessary
	2 Pentothal	If airway may easily be maintained
	Children	
	1 Vinyl ether open drop	
Fenestration Operation		
Clinical 1 Only in adults with few exceptions 2 Elective Subjects in good condition 3 Upright position *Surgical* 1 Tedious and meticulous 2 Perfect hemostasis required (hypotensive anesthesia may be needed) 3 May use dental drill *Anesthetic* 1 Airway difficult to control	1 Cyclopropane intratracheally	
	2 Thiopental basal nitrous oxide with topical	
	3 Ether preceded by nitrous oxide or ethylene	
	Not Desirable	
	1 Insufflation ether	

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
9 Mouth—Dental Extractions		
Clinical 1 Patients usually in excellent condition 2 General anesthesia used for children quite frequently *Surgical* 1 Often done in sitting position 2 May be lengthy particularly in extracting impacted molars 3 Jaw must be relaxed 4 Packs must be used 5 Surgeon must have access to mouth and head 6 Oral sepsis often present *Anesthetic* 1 Airway difficult to maintain 2 Secretions and blood fall backward into pharynx	1 Nerve blocks	Best selection for office use
	2 Nitrous oxide with vinethene by nasal mask	For office use for simple extractions
	3 Nitrous oxide-trichlorethylene with nasal mask	For office use for simple extractions
	4 Cyclopropane intratracheally	For extensive and multiple extractions in hospitals
	5 Ether intratracheally preceded by nitrous oxide	Nausea vomiting unpleasant
	6 Nitrous oxide intratracheally and basal pentothal	Not flammable
	Less Desirable or Contraindicated	
	7 Pentothal alone	Laryngeal spasm and respiratory depression common in postoperative period
	8 Nitrous oxide alone	Possibility of asphyxia too great
	Children 1 Vinethene by open drop 2 Nitrous oxide with vinethene 3 Cyclopropane or ether intratracheally 4 Ether by insufflation	
10 Mouth—Operations on Tongue Salivary Glands Palate Gums		
Clinical 1 Oral sepsis often present *Surgical* 1 Surgeon must have access to mouth 2 Blood and secretions pass back into pharynx and larynx 3 Relaxation of jaw muscles required 4 May be lengthy 5 Pharyngeal packs may be used 6 May use cautery *Anesthetic* 1 Airway difficult to maintain without *nasal endotracheal tube* 2 Lesion may offer obstruction	1 Cyclopropane intratracheally (nasal)	Allows rapid induction and recovery
	2 Ether intratracheally (nasal) route preceded by nitrous oxide or ethylene	Used when cyclopropane is not desired
	3 Basal pentothal—nitrous oxide intratracheally	Used when fire hazard exists
	4 Nerve blocks	Not satisfactory for extensive procedures or patients who are not cooperative
	Less Desirable	
	5 Insufflation orally	Not advised—airway difficult *to maintain*
	Children 1 Cyclopropane intratracheally 2 Ether intratracheally 3 Basal pentothal—nitrous oxide intratracheally	
11 Lip—Plastic Operations—Resection for Neoplasm Removal of Scars		
Clinical 1 Oral sepsis often present 2 May be in any age group *Surgical* 1 Surgeon must have access to mouth 2 Blood and secretions pass into pharynx and larynx 3 Relaxation of jaw muscles required 4 May be lengthy 5 Pharyngeal packs may be used *Anesthetic* 1 Airway difficult to maintain without nasal endotracheal tube	1 Local or nerve block	For simple non extensive procedures
	2 Cyclopropane intratracheally	Best choice when local cannot be used
	3 Nitrous oxide or ethylene followed by ether	Used when cyclopropane is not desired
	4 Basal pentothal—nitrous oxide intratracheally	Used when a fire hazard exists
	5 Insufflation of ether	Not advised—airway not under control
	Children	
	1 Cyclopropane or ether intratracheally (oral)	
	2 Basal pentothal—nitrous oxide intratracheally	Used when cautery is required
	3 Local or nerve blocks	Subjects may not be cooperative
	4 Insufflation of ether	Airway not under complete control

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
12 Jaw—Mandible—Resections Curettements Reduction of Fractures Plastic on Joint etc		
Clinical		
1 Fractures common in alcohol addicts 2 Subjects are most often adults 3 Oral sep is often present	1 Cyclopropane intratracheally	Permits rapid induction and recovery
Surgical	2 Ether intratracheally	Used when cyclopropane is not desired
1 Patient may not be able to open mouth due to trauma or disease of joint 2 Teeth may be wired together 3 May be prolonged and accompanied by blood loss	3 *Basal pentothal—nitrous oxide*	*Post anesthetic depression is* common and objectionable
	Less Desirable	
	4 Ether by insufflation	Airway almost impossible to control
Anesthetic	*Children*	
1 Airway difficult to maintain without endotracheal tube 2 Mask may be difficult to apply to face—intubate with local—patient awake	1 Cyclopropane intratracheally 2 Ether intratracheally 3 Basal pentothal—nitrous oxide intratracheally (with topical)	
		Jaws must be fixed after post anesthetic retching and vomiting has ceased (If jaws are fixed insert oronasal tube before removing naso-endotracheal tube and aspirate secretion through it)
13 Jaw—Upper—Resection of Maxilla Reduction of Fractures Removal of Neoplasms Curettements		
Clinical		
1 Usually older adults 2 Fractures associated with other injuries	1 Basal of pentothal nitrous oxide	Non flammable
	2 Cyclopropane intratracheally	*Flammable Used if cautery is* not
Surgical	3 Ether intratracheally	Flammable Used if cautery is not
1 May be long radical procedures 2 Considerable blood loss may occur May require hypotensive anesthesia 3 Cautery may be used for hemostasis 4 Surgical site often includes nasal passages	*Less Desirable or Contraindicated*	
	4 Nerve blocks or local	Satisfactory relief rarely obtained
	5 Insufflation of ether	Airway not under control Flammable
Anesthetic	6 Pentothal alone or combined with curare	Prolonged depression Airway not under control
1 Maintenance of airway requires use of intratracheal tube 2 Presence of lesion does not permit mask to be applied to face 3 Tracheotomy may be required prior to surgery 4 Blood and secretions may pass into nasopharynx		
14 Jaw—Upper—Maxilla—Sinuses—Antrotomy—Caldwell Luc Removal of Polyps etc		
Clinical		
1 Post nasal drainage often present 2 Nasal passages frequently occluded or distorted 3 Chronic bronchitis or allergy may be associated with the condition	1 Nerve block	Best to use but not always feasible
	2 Cyclopropane intratracheally	Permits adequate control of airway Rapid induction and recovery
Surgical	3 Pentothal—nitrous oxide intratracheally	Postoperative depression may follow long operations
1 May be long and radical 2 May be traumatic with considerable bleeding	4 Ether intratracheally	Slow recovery after long operations
	5 Ether by insufflation	Airway not under control
Anesthetic	*Children*	
1 Anesthetist must be removed from surgical site Endotracheal (oral) tube required	Same as adults	

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
9 Mouth—Dental Extractions		
Clinical		
1 Patients usually in excellent condition	1 Nerve blocks	Best selection for office use
2 General anesthesia used for children quite frequently	2 Nitrous oxide with vinethene by nasal mask	For office use for simple extractions
Surgical	3 Nitrous oxide-trichlorethylene with nasal mask	For office use for simple extractions
1 Often done in sitting position	4 Cyclopropane intratracheally	For extensive and multiple extractions in hospitals
2 May be lengthy particularly in extracting impacted molars	5 Ether intratracheally preceded by nitrous oxide	Nausea vomiting unpleasant
3 Jaw must be relaxed	6 Nitrous oxide intratracheally and basal pentothal	Not flammable
4 Packs must be used	*Less Desirable or Contraindicated*	
5 Surgeon must have access to mouth and head	7 Pentothal alone	Laryngeal spasm and respiratory depression common in postoperative period
6 Oral sepsis often present	8 Nitrous oxide alone	Possibility of asphyxia too great
Anesthetic	*Children*	
1 Airway difficult to maintain	1 Vinethene by open drop	
2 Secretions and blood fall backward into pharynx	2 Nitrous oxide with vinethene	
	3 Cyclopropane or ether intratracheally	
	4 Ether by insufflation	
10 Mouth—Operations on Tongue Salivary Glands Palate Gums		
Clinical		
1 Oral sepsis often present	1 Cyclopropane intratracheally (nasal)	Allows rapid induction and recovery
Surgical	2 Ether intratracheally (nasal) route preceded by nitrous oxide or ethylene	Used when cyclopropane is not desired
1 Surgeon must have access to mouth	3 Basal pentothal—nitrous oxide intratracheally	Used when fire hazard exists
2 Blood and secretions pass back into pharynx and larynx	4 Nerve blocks	Not satisfactory for extensive procedures or patients who are not cooperative
3 Relaxation of jaw muscles required		
4 May be lengthy		
5 Pharyngeal packs may be used		
6 May use cautery		
Anesthetic	*Less Desirable*	
1 Airway difficult to maintain without nasal endotracheal tube	5 Insufflation orally	Not advised—airway difficult to maintain
2 Lesion may offer obstruction	*Children*	
	1 Cyclopropane intratracheally	
	2 Ether intratracheally	
	3 Basal pentothal—nitrous oxide intratracheally	
11 Lip—Plastic Operations—Resection for Neoplasm Removal of Scars		
Clinical		
1 Oral sepsis often present	1 Local or nerve block	For simple non extensive procedures
2 May be in any age group	2 Cyclopropane intratracheally	Best choice when local cannot be used
Surgical	3 Nitrous oxide or ethylene followed by ether	Used when cyclopropane is not desired
1 Surgeon must have access to mouth	4 Basal pentothal—nitrous oxide intratracheally	Used when a fire hazard exists
2 Blood and secretions pass into pharynx and larynx	5 Insufflation of ether	Not advised—airway not under control
3 Relaxation of jaw muscles required		
4 May be lengthy		
5 Pharyngeal packs may be used		
Anesthetic	*Children*	
1 Airway difficult to maintain without nasal endotracheal tube	1 Cyclopropane or ether intratracheally (oral)	
	2 Basal pentothal—nitrous oxide intratracheally	Used when cautery is required
	3 Local or nerve blocks	Subjects may not be cooperative
	4 Insufflation of ether	Airway not under complete control

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
18 Larynx—Tracheotomy		
Clinical 1 Obstruction and asphyxia are present or eminent *Surgical* 1 May be performed prophylactically 2 Urgent in emergencies	1 No anesthesia 2 Local 3 Intratracheal cyclopropane 4 Intratracheal ether 5 Nitrous oxide intratracheally preceded by pentothal *Children* Same	Emergency only For elective procedures with obstruction Elective without obstruction For elective cases
19 Larynx—Laryngectomy		
Clinical 1 Are in older age group as rule 2 Usually are in fair condition but may be emaciated 3 Dyspnea may be present due to obstruction at larynx *Surgical* 1 Are usually long tedious 2 Requires tracheotomy as soon as larynx is removed 3 Blood loss and shock may occur 4 Cautery may be used *Anesthetic* 1 Anesthetist and surgeon compete for operative field 2 Possibility of vagal reflexes from manipulation of larynx.	1 Cyclopropane intratracheally with topical 2 Ether intratracheally 3 Basal of pentothal with nitrous oxide intratracheally and muscle relaxant *Not Desired* 4 Pentothal alone 5 Local 6 Ether by insufflation	As soon as larynx is removed a tracheal tube is inserted until time of tracheotomy Used when cyclopropane is not desired When 1 or 2 are not desired or if fire hazard exists Spasm obstruction prolonged depression follow Difficult to establish complete pain relief Airway not easily controlled
20 Bronchi—Bronchograms		
Clinical 1 Usually performed for diagnosis when suppurative disease of the lung is present 2 May be anemic and emaciated 3 Usually have pulmonary disfunction 4 Occurs in any age group but frequently in children *Surgical* 1 Requires insertion of cannula and injection of oily opaque substance 2 Are not long as a rule 3 Relaxation and cooperation of patient required 4 Done in fluoroscopic room in dark. *Anesthetic* 1 Coughing bronchospasm and diminished ventilation follow injection of contrast media 2 Airway must be maintained 3 Explosion hazard present 4 Must remain anesthetized until X Rays are taken 5 Apnea necessary at time of X Ray 6 Vagal reflexes may be initiated (administer atropine pre anesthetically)	1 Topical 2 Cyclopropane intratracheally 3 Ether intratracheally 4 Basal pentothal or avertin topical with nitrous oxide intratracheally 5 Ether by insufflation *Children* 1 Ether open drop	Best choice but patient may not always be cooperative Desirable but is flammable X Ray unit used Desirable but is flammable X Ray unit used Not flammable Respiratory depression common Possibil of laryngeal and bronchospasm enhanced by the basal Not advised Airway not under control Fire hazard Excessive secretions

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
15 Pharynx—Tonsillectomy and Adenoidectomy		
Clinical		
1 May have chronic respiratory infection	1 Local	Best choice if patient tolerates it
2 Are usually young subjects	2 Cyclopropane oratracheally or nasotracheally if adenoids are not large	Surgeons often complain of oozing Ideal for the purpose otherwise
Surgical		
1 Brief Time varies with operator	3 Ether as in 2 above	Recovery not as rapid as with cyclopropane Effects of ether on patient
2 Difficulty in controlling hemorrhage may be encountered		
3 Require postoperative endotracheal suction	4 Nitrous oxide muscle relaxant and basal of pentothal	Respiratory depression follows in postoperative period
4 Relaxation of jaw required		
Anesthetic	5 Insufflation of ether	Difficult to maintain airway and satisfactory depth of anesthesia in adults Aspiration occurs
1 Surgeon must have access to both mouth and nasopharynx		
2 Lymphoid tissue obstructs airway		
	Not Desired	
	1 Pentothal alone	Spasm and obstruction frequent and impossible to obviate
	Children	
	1 Vinyl ether induction and insufflation of ether with oxygen	Simple but does not assure adequate airway Aspiration of blood occurs
	2 Oratracheal intubation with ether or cyclopropane	Possibility of trauma to trachea and larynx Aspiration minimized
	3 Basal of pentothal rectally ether intratracheally	Respiratory depression objectionable
	4 Basal pentothal ether by insufflation	Airway not maintained adequately Respiratory depression objectionable
16 Pharynx—Drainage of Peritonsillar or Retropharyngeal Abscess		
Clinical		
1 May not be able to open mouth	1 Local	Best and most frequent choice
2 Septic with fever	2 Cyclopropane nasotracheally	Abscess may be ruptured in attempting intubation
Surgical		
1 Usually brief	3 Ether by insufflation	May aspirate Airway not under control
Anesthetic		
1 Airway difficult to maintain without endotracheal tube		
2 Abscess may rupture during induction or intubation. Aspiration may occur		
17 Larynx—Removal of Polyps Diagnostic Suspensions Operations on Cords etc		
Clinical		
1 Dyspnea orthopnea often present	1 Local	Useful for simple endoscopic procedures
2 Common in children		
3 May have tracheotomy	2 Topical followed by ultra short acting barbiturate intravenously with muscle relaxant	Not ideal but best available at present time Spasmogenic Spasms precipitated by instrumentation blood and secretions
Surgical		
1 Relaxation required for exposure of larynx		
2 May be long	3 Ether by insufflation	Distasteful to patient difficult to maintain at proper depth Secretions
3 Surgical procedure may induce bleeding		
Anesthetic	4 Cyclopropane by insufflation	Not advised Costly and creates fire hazard
1 Anesthetist and surgeon both compete for airway	*Children*	
2 Cough reflex difficult to abolish	1 Ether by insufflation	Not best but safest and simplest to use
3 Obstruction present prior to inception of anesthesia	2 Cyclopropane by insufflation	For small infants
4 Tracheotomy may be advisable prior to anesthesia if airway is inadequate	3 Basal of pentothal or avertin followed by 1 or 2	Spasm may result Respiratory depression in postoperative period

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
	NECK	
23 Anterior—Thyroidectomy (for Toxic and Non Toxic Goitres)		
Clinical 1 May have associated heart disease (in toxic goiter high pulse pressure rapid pulse) 2 May have cord paralysis edema of larynx tracheitis deviated trachea 3 Are apprehensive and highly excitable 4 Do not withstand epinephrine and sympathomimetic amines 5 Have a high metabolic rate and are emotionally unstable 6 Have have intrathoracic mass 7 May have associated myesthenia gravis	1 Ethylene or nitrous oxide followed by ether intratracheally combined with basal narcosis using morphine scopolamine avertin or intravenous ultra short or short acting barbiturate	Allows maintenance of airway avoidance of excitement smooth induction and maintenance
	2 Cyclopropane and basal narcosis described above	Increases cardiac irritability in toxic cases
	Less Desirable or contraindicated	
Surgical 1 Relaxation a minor factor 2 Head must be hyperextended for exposure 3 Surgeon competes with anesthetist for operative field 4 Oozing and bleeding commonly occur 5 May require several hours	3 Local or cervical plexus block	Apprehension present Do not tolerate epinephrine and sympathomimetic amines
	4 Pentothal-curare nitrous oxide intratracheally	Not anesthetic. Depression in the postoperative period
	5 Open or closed anesthesia without intratracheal tube	Airway not under control Thyroid crisis and cardiac failure may occur Tracheitis and cord paralysis may follow
Anesthetic 1 High oxygen consumption and carbon dioxide output 2 Possibility of heat retention and hyperthermia 3 Exophthalmos may interfere with application of mask 4 Airway maintained with difficulty when intubated 5 Iodides may cause excessive secretions 6 Circulatory changes such as tachycardia irregularities hypertension common	*Children* 1 Same as adult 2 Non toxic—same as above 3 Intrathoracic—same as above	
24 Anterior—Dissections Vascular Surgery Skin Grafts etc		
Clinical 1 Usually older adults 2 Usually performed on fair risk	1 Cyclopropane intratracheally	Rapid induction and recovery
Surgical 1 Are long procedures and tedious 2 No relaxation needed	2 Nitrous oxide or ethylene followed by ether intratracheally	Suitable when cyclopropane is contraindicated
Anesthetic 1 Airway difficult to maintain unless intubated 2 Carotid sinuses may be active giving rise to respiratory and circulatory changes 3 Anesthetist must be away from operative field 4 Distortion of face from previous surgery may prevent application of mask	3 Pentothal combined with nitrous oxide intratracheally with topical	Suitable for short procedures or when cautery is used
	4 Infiltration with local anesthesia	Minor short procedures in cooperative patients
	5 Cervical plexus block	Suitable in cooperative non extensive procedures
	Undesirable	
	6 Ether open drop and insufflation	Secretions excessive airway not maintained safely
	7 Any general anesthetic without intratracheal airway	For superficial brief procedures without obstruction
	Children	
	1 Cyclopropane intratracheally	Advised As above
	2 Vinethene open drop followed by ether open drop	Not advised Airway not under control

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
21 Bronchi—Bronchoscopy		
Clinical		
1 May have copious secretions if suppurative disease of lungs is present	1 Topical with sedation	Best choice but may be unsuitable if patient is uncooperative
2 May have hyperactive cough reflex		
3 Dyspnea and pulmonary dysfunction may be present if done for pulmonary disease	2 Basal of pentothal topical and muscle relaxant	Simplest to induce but hazardous from standpoint of bronchospasm and postoperative respiratory depression
4 Pressure symptoms may be present giving rise to obstruction		
5 Patient not confined to any particular age group	3 Ether by insufflation preceded by closed or open drop induction	Disagreeable prolonged and difficult induction and difficult maintenance Safest but not best
Surgical	4 Cyclopropane by insufflation preceded by basal of pentothal	Expensive and impractical Explosion hazard greater than with ether
1 Usually performed for diagnosis removal of foreign body and therapeutically to remove secretions		
2 Usually brief in skilled hands	*Children*	
3 Massive hemorrhage may be caused by trauma	1 Ether open drop followed by insufflation	Safest simplest Ether distorts light and interfers with proper vision
4 Relaxation needed for exposure of larynx	2 Cyclopropane by insufflation	Expensive and impractical Explosion hazard greater than with ether
5 Vagal and cough reflexes are initiated from instrumentation		
6 Symptoms of anoxia arise if pulmonary dysfunction is present	3 Basal and muscle relaxant and topical	Simplest to induce but hazardous from standpoint of bronchospasm and postoperative respiratory depression
7 Performed in a darkened room		
	4 Local	Children are not cooperative for this technique
22 Esophogoscopy		
Clinical		
1 Patient may be emaciated due to poor nutrition	1 Topical with sedation	Suitable for cooperative patients
2 Patient may be apprehensive (cardiospasm)	2 Cyclopropane intratracheally and muscle relaxant and topical	Rapid induction and recovery Ideal for this type of work
3 Usually in older age group		
4 Usually performed for diagnosis or removal of foreign bodies	3 Basal of pentothal nitrous oxide intratracheally and muscle relaxant and topical	Suitable but if procedure is prolonged an excess of drug causes respiratory depression
Surgical		
1 Requires relaxation for exposure	4 Ether intratracheally and topical	Ether is disagreeable to patient Relaxation excellent Long induction and slow recovery
2 Cooperation of patient required		
3 Intratracheal tube distresses most surgeons		
Anesthetic	*Less Desirable*	
1 Surgeon and anesthetist compete for operative field	5 Ether by insufflation	Not recommended Airway not under control
2 Mucous vomiting and retching may occur	6 Pentothal or avertin alone	Airway not under control Spasm and respiratory depression result
3 Vagal reflexes may be initiated by instrumentation		
	Children	
	1 Vinyl ether—open drop ether insufflation of ether	Usual method Airway not easily maintained
	2 Cyclopropane intratracheally	Desirable but surgeon objects to intratracheal catheter
	3 Basal with cyclopropane or nitrous oxide with muscle relaxant	Respiratory depression common from basal

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
28 Chest Wall—Radical Mammectomy		
Clinical	1 Cyclopropane	Rapid acting rapid recovery
1 Usually in middle aged and older women	2 Nitrous oxide or ethylene with basal	When cyclopropane or ether are not desired
2 Disease usually not far advanced in cases selected for radical	3 Nitrous oxide or ethylene followed by ether	When contraindication exists to basal narcosis or cyclopropane
3 Patients often apprehensive and upset by coming ordeal		
Surgical	*Not Desirable or Contraindicated*	
1 Relaxation not needed	4 Local infiltration	Not satisfactory from psychic and surgical standpoint
2 Are long tedious		
3 May require skin grafting	5 Intercostal or paravertebral block	Same as above
4 Blood loss may be considerable		
5 Electrosurgical unit may be used for hemostasis		
Anesthetic		
1 Anesthetist has control of airway No tube needed unless patient is obese or has other factors affecting airway		

	CHEST	
29 Pleura—Drainage of Empyema		
Clinical	1 Paravertebral block or intercostal block	Permits upright position and dependent drainage
1 Signs and symptoms of sepsis	2 Cyclopropane intratracheally	When block anesthesia is not feasible Permits rapid induction and high oxygen
2 Decreased pulmonary reserve usually present.	3 Nitrous oxide or ethylene with ether intratracheally	Possibility of decreased oxygen during induction not desirable
3 Cough dyspnea or orthopnea	4 Nitrous oxide intratracheally—basal of pentothal	Depression of respiration spasm and prolonged somnolence may occur
4 Possibility of bronchial communications present		
5 Associated pneumonitis is common		
6 Possibility of cerebral abscess		
Surgical		
1 No relaxation required		
2 Usually requires rib resection		
3 May be done in sitting position	*Not Desirable or Contraindicated*	
Anesthetic	5 Open drop ether	Insufficient oxygen excess secretions and lack of adequate airway
1 Airway may be difficult to maintain due to secretions and position	6 Any of above without an endotracheal tube	Lack of adequate airway
2 Respiratory distress may interfere with ventilation		

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
25 Anterior—Incisions and Drainages of Phlegmons and Abscesses		
Clinical		
1 May be septic from infection	1 Intubation awake with topical anesthesia followed by cyclopropane	Airway under control at all times—rapid return of reflexes
2 May be obstructed and orthopneic.	2 Same followed by nitrous oxide or ethylene with ether oxygen sequence	Return of reflexes delayed by ether
3 May be associated with diabetes leukemia or other systemic diseases	3 Same as above but using pentothal—nitrous oxide	Respiratory depression prolonged Possibility of obstruction postoperative increased
4 Inflation may follow dental extractions or mouth lesion	4 Tracheotomy under local followed by cyclopropane ether or pentothal and nitrous oxide	Mandatory when dyspnea and orthopnea due to obstruction is present
Surgical	5 Local	Suitable for brief superficial operations only
1 Not lengthy	*Less Desirable or Contraindicated*	
2 Relaxation not needed	1 Inhalation anesthesia basal narcosis without intratracheal airway	Asphyxia from obstruction may result
Anesthetic	2 Cervical plexus block	Not desirable in presence of infections
1 May have edema of floor of mouth pharynx, neck etc. Airway is invariably difficult to maintain		
2 Inability to swallow may be present—saliva accumulates in mouth		
26 Posterior—Dissections Skin Grafts Incision and Drainages etc.		
Clinical		
1 May be septic if surgery is for infection.	1 Cyclopropane intratracheally	Rapid induction and recovery
2 Patient may be in any age group	2 Nitrous oxide or ethylene ether-oxygen sequence intratracheally	Delayed return of reflexes in long operations
Surgical	3 Nitrous oxide and a basal of pentothal	Depressed respiration, delayed return of reflexes.
1 Relaxation not needed	4 Local.	Suitable for brief simple procedures
2 Usually not long and extensive	5 Cervical plexus block.	Recommended in brief superficial procedures in suitable subjects
Anesthetic	*Less Desirable or Contraindicated*	
1 Awkward positions (prone or lateral) is used Airway difficult to control	6 Inhalation or intravenous anesthesia without an endotracheal airway	Asphyxia is an ever present danger
2 Anesthetist must be away from surgical field	*Children*	
3 Circulatory changes may occur due to positional changes	Same as for adults	

THORAX

Problems Encountered	*Choices*	*Remarks*
27 Chest Wall—Biopsies—Plastic Operations Excision of Masses Drainage of Abscesses etc.		
Clinical		
1 Physical status usually good	1 Cyclopropane	Permits rapid induction and recovery
2 Usually are adults.	2 Nitrous oxide or ethylene with basal	Suitable for short procedures
Surgical		
1 No relaxation required	3 Nitrous oxide or ethylene followed by ether	Prolonged recovery and undesirable after effects
2 Vary in duration.		
2 May use electrosurgical unit.	4 Local infiltration.	Suitable for minor less extensive procedures
Anesthetic		
1 Supine position unless operative site is on back for which an endotracheal tube is required	5 Intercostal or paravertebral block	Can only be used for operations which are in the mid and lower thorax
2 Anesthetist has control of head		

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
	Thorax	
30 Pleura—Thoracoplasty		
Clinical		
1 Ordinarily performed for tuberculosis or after pneumonectomy to obliterate space in chest	1 Cyclopropane intratracheally	Allows adequate oxygenation is stable and permits rapid recovery
2 Decreased pulmonary reserve usually present	2 Ether preceded by cyclopropane—ethylene or nitrous oxide	Used when cyclopropane is not desired
3 Anemia fever weight loss and other factors incident to disease are present	3 Nitrous oxide or ethylene with basal of pentothal	Accompanied by bronchial spasm May be followed by respiratory depression
4 Tuberculous tracheitis may be present Intratracheal tube may aggravate it	4 Paravertebral block	Not suitable for psychic reasons and from standpoint of duration
5 Tracheobronchial fistula may be present Closed system difficult to maintain	5 Local	Not always technically feasible
Surgical	6 Peridural block	
1 Shock due to trauma from removal of ribs and blood loss common	*Not Desirable or Contraindicated*	
2 No relaxation needed	1 Spinal	
3 May be prolonged		
4 Cautery may be necessary for hemostasis		*Complications*
Anesthetic		Shock not uncommon at conclusion
1 Patient is on side—Airway		Tension pneumothorax
2 Circulatory changes due to posture reflexes and pleural stimulation		Air Emboli
3 Excessive secretions may be present		Respiratory acidosis
4 Carbon dioxide retention due to inadequate ventilation from posture		
5 Positive pressure or controlled respiration may be required		
31 Lung—Pneumonectomy Lobectomy Exploratory Thoracotomy		
Clinical		
1 Diminished pulmonary reserve present	1 Cyclopropane intratracheally	Allows quiet breathing Mediastinum does not move excessively
2 Usually sepsis or a neoplasm or both are present	2 Cyclopropane followed by ether	Ether causes exaggerated respiratory movements and enhances production of secretions
3 Left vocal cord paralysis (neoplastic) may be present	3 Nitrous oxide or ethylene followed by ether intratracheally	Induction may be prolonged and difficult and accompanied by sub oxygenation
4 Atelectasis may be present	4 Nitrous oxide—pentothal and a muscle relaxant	Respiratory pattern disturbed Respiratory depression follows postoperatively Bronchial spasm frequent
Surgical		
1 May be long and tedious	*Less Desirable or Contraindicated*	
2 No relaxation needed	1 Local or regional blocks	Complete block cannot be obtained
3 Adhesions may give rise to ooze causing considerable blood loss	2 Spinal	Respiratory paralysis and hypotension cannot be averted or controlled
4 Shock and hemorrhage likely	3 Basal narcotics alone or with local	Respiratory depression bronchial spasm and lack of control of airway are objectionable
Anesthetic	*Children*	*Complications*
1 Copious secretions require frequent suctioning	Same as adults	Respiratory acidosis may contribute to shock
2 Awkward position interferes with ventilation		Positional changes may induce shock at conclusion of surgery
3 Vagal hilar and tracheobronchial reflexes may cause circulatory disturbances		Inadequate ventilation follows due to removal of lung
4 Mediastinal shift and inadequate ventilation due to open chest may require controlled breathing		Emergence delerium from anoxia not uncommon
5 Coughing and bronchial spasm make induction difficult		Pulmonary edema from overloading with fluid may occur
		Subcutaneous emphysema
		Pneumothorax or mediastinal emphysema may occur

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
38 Oesophagus—Resections Removal of Diverticulae etc		
Clinical 1 Patients are usually adults in older age groups 2 Cachexia anemia etc due to interference with nutrition may be present *Surgical* 1 Requires open chest as for thoracic portions 2 Long tedious time consuming 3 Retention may be present *Anesthetic* 1 Same as for pneumonectomy and other intrathoracic procedures In addition presence of stomach tube interferes with application of mask 2 Possibility of aspiration of contents of diverticuli 3 Reflex changes due to manipulation of vagi	1 Cyclopropane intratracheally 2 Cyclopropane combined with ether intratracheally 3 Nitrous oxide or ethylene followed by ether intratracheally 4 Pentothal nitrous oxide 5 Local or cervical block.	Labile permits rapid induction and recovery Suitable when cyclopropane alone cannot be used Suitable when cyclopropane cannot be used Respiratory depression common Used for surgery upon cervical portion particularly in diverticulectomy
39 Diaphragm—Repair of Hernia Eventrations etc.		
Clinical 1 Respiratory distress may be present due to eventration of abdominal contents into thorax. 2 Possible gastric retention due to stasis *Surgical* 1 May require transabdominal and thoracic approach *Anesthetic* 1 May require controlled respiration 2 May encounter troublesome reflexes due to manipulation of phrenics or vagi 3 Disturbances in ventilation may result from manipulation of diaphragm	1 Cyclopropane intratracheally 2 Ethylene or nitrous oxide followed by ether intratracheally 3 Nitrous oxide intratracheally Basal of pentothal *Not Desired* 4 Local 5 Spinal	Labile rapid acting Causes quiet breathing Exaggerates breathing Suitable if apnea is required for controlled respiration Depression in postoperative period

Abdomen

Problems Encountered	*Choices*	*Remarks*
40 Upper—Biliary Gastric Splenic Hepatic Pancreatic Surgery Repair of Epigastric Hernia etc.		
1 Anemia jaundice sepsis weight loss or other factors incident to the disease may be present 2 Patients may be in any age group *Surgical* 1 Relaxation required 2 May be prolonged tedious 3 Quiet abdomen essential *Anesthetic* 1 Troublesome traction reflexes cause laryngeal and bronchial spasm and circulatory changes 2 Possibility of retention in gastric cases 3 Stomach tube may be required Interferes with mask. 4 Shock may follow in long cases	1 Cyclopropane intratracheally with a muscle relaxant 2 Ether intratracheally induced with ethylene or nitrous oxide with or without a basal 3 Nitrous oxide pentothal and a muscle relaxant 4 Spinal with basal narcosis or light cyclopropane or ethylene 5 Field block or intercostal block combined with a splanchnic block. *Children* 1 Ether — non rebreathing technique 2 Ether or cyclopropane closed system 3 Open drop ether	Provides quiet abdomen Excellent relaxation obtained May have prolonged recovery period in long operations Respiration may be exaggerated Depression postoperatively may follow particularly in prolonged operations Traction causes chest pain nausea vomiting Incidence of atelectasis greater than with other methods Useful in poor risk subjects but not always satisfactory or of sufficient duration

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
35 Heart—Myocardium—Correction of Congenital Defects (Tetralogy of Fallot)		
Clinical 1 May have expanded blood volume May have high venous pressure Most subjects are children 2 Usually have high hematocrit and blood viscosity 3 Have decreased arterial blood oxygen saturation as a rule Orthopnea and dyspnea *Surgical* 1 No relaxation needed 2 Requires open thorax and rib resection 3 Meticulous Are done in supine or lateral position *Anesthetic* 1 Open chest required—positive pressure or controlled breathing necessary 2 Attempt to reduce oxygen consumption by (a) relieving apprehension (b) reducing metabolic rate 3 Cardiac irregularities may develop 4 Cardiac failure may develop 5 Cerebral thrombosis may develop	1 Ether intratracheally induced with cyclopropane or nitrous oxide or ethylene with or without basal narcosis Hypothermia as adjunct 2 Cyclopropane intratracheally with or without basal 3 Pentothal—nitrous oxide *Not Desired* 4 Local or nerve block	Most suitable from cardiac standpoint Increases cardiac irritability Depression of respiration common
36 Heart—Myocardium—Correction of Patent Ductus Arteriosus		
Clinical 1 Most subjects are children Decreased diastolic pressure and widened pulse pressure 2 Cardiac enlargement is present Symptoms of cardiac insufficiency more common in adults *Surgical* 1 Open chest 2 Patient must be on side 3 Hemorrhage a possibility 4 Requires quiet mediastinum *Anesthetic* 1 Lateral position requires use of intratracheal airway	1 Ether intratracheally May be induced with cyclopropane or nitrous oxide or ethylene with or without basal narcosis 2 Pentothal basal nitrous oxide or ethylene intratracheally *Not Desirable* 3 Cyclopropane alone 4 Local	Most suitable from cardiac standpoint Depression of respiration common Increases cardiac irritability
37 Heart—Myocardium—Valvulotomy and Repairs of Other Intracardiac Defects Suture of Perforations		
Same requirements as for correction of congenital defects except that there is increased cardiac irritability due to intracardiac manipulation	1 Ether intratracheally Induced with cyclopropane or nitrous oxide or ethylene with or without basal narcosis 2 Cyclopropane intratracheally	

TABLE II (continued)

Problems Encountered	Choices	Remarks
44 Intra Abdominal Extra Peritoneal—Bladder Operation Cystotomy Cystectomy Resection Diverticulectomy		
Clinical	1 Spinal	Satisfactory for most subjects because low one is required
1 May have urinary retention with or without azotemia	2 Cyclopropane	Rapid recovery and induction
2 More common in older age group	3 Nitrous oxide or ethylene followed by ether	Less desirable
Surgical	4 Nitrous oxide and a basal of pentothal and muscle relaxant	Depression occurs postoperatively Not flammable
1 Are usually done suprapubically and extra peritoneally	5 Local	Suitable for cystotomy or other minor procedures
2 Require muscle relaxation	6 Caudal	Satisfactory for transurethral approach only if caudal is high
3 May use electrosurgical unit		
4 May require distention of bladder with water—Some may be absorbed or forced intravenously		
Anesthetic		
1 Time variable—resections prolonged cystotomies brief		
2 Traction reflexes common		
45 Bladder—Cystoscopy		
Clinical	1 Trilene analgesia	For office or outpatient use for diagnosis
1 Condition of patient variable	2 Nitrous oxide-oxygen	For short procedures or for diagnosis
Surgical	3 Nitrous oxide and pentothal	For longer more extensive procedures in apprehensive subjects
1 Relaxation usually not required	4 Spinal	When extensive anesthesia and relaxation is required
2 Are performed for diagnosis or for therapy—Removal of stones		
3 Are more painful in males		
4 Patients may be in any age group		
5 Are performed in lithotomy position		
46 Extra Peritoneal—Operations on Kidney and Ureters		
Clinical	1 Cyclopropane intratracheally	Causes little or no metabolic disturbances
1 Sepsis tuberculosis or other evidence of infection may be present	2 Cyclopropane combined with ether intratracheally	Needed for good relaxation
2 Uremia or urinary suppression may be present	3 Spinal—with sedation	Must be high to abolish reflexes from traction
3 Abdominal distention may be present (reflex in colic)	4 Ether preceded by ethylene or nitrous oxide intratracheally	Satisfactory when 1 2 and 3 are not desired
4 Debilitation and other signs of systemic disease	5 Basal of pentothal nitrous oxide intratracheally with a muscle relaxant	Prolonged depression occurs in postoperative period particularly in chronically ill patients
Surgical	*Children*	
1 Usually performed in lateral position (prone for lower ureters)	1 Ether or cyclopropane intratracheally by closed system	
2 Muscle relaxation required	2 Ether open drop	When closed system is not available
3 Adrenal gland may be manipulated		
4 Peritoneum may be manipulated		
5 Blood loss may be considerable		
Anesthetic		
1 Intratracheal airway indicated for lateral position		
2 Troublesome reflexes from traction on renal pedicle may cause respiratory and circulatory changes		
3 Hormonal effects from manipulation of adrenal may occur		
4 Nausea and vomiting from traction reflexes (spinal or local)		
5 Positive pressure may be needed if pleura is incised		

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
41 Lower—Intestinal Operations Appendectomy Operations of Pelvic Organs etc		
Clinical 1 Patients may be in any age group 2 Anemia weight loss sepsis and other factors incident to the disease may be present *Surgical* 1 Relaxation required 2 May be long and tedious 3 Quiet abdomen essential 4 Performed in supine position *Anesthetic* 1 Troublesome laryngeal and bronchial reflexes 2 Possibility of aspiration from obstruction or retention 3 Stomach tube may be required Interferes with mask 4 Shock may occur in long cases	1 Spinal	Yields excellent relaxation
	2 Cyclopropane with a muscle relaxant	Excellent when spinal is not desired
	3 Ethylene or nitrous oxide followed by ether	When 1 and 2 are not desired or contraindicated
	4 Nitrous oxide pentothal and a muscle relaxant	When cautery is used Depression undesirable
	5 Abdominal field block with basal or gaseous agent	For poorer risk patients
	Less Desirable or Contraindicated	
	6 Open drop ether	Suitable when nothing else is available
	7 Nitrous oxide or ethylene alone	Does not yield relaxation
	8 Pentothal alone	Insufficient depth and potency with safe limits
	Children	
	1 Cyclopropane—ether closed system	
	2 Vinethene-ether	
42 Wall—Extra Peritoneal Procedures Removal of Cysts, Lipomas Skin Grafts etc Plastic Operations		
Clinical 1 Patients usually in good condition 2 Patients may be in any age group *Surgical* 1 Usually superficial or minor 2 Relaxation not needed 3 Usually in supine position *Anesthetic* 1 Anesthetist has ready access to airway	1 Local or field block	For brief superficial operation
	2 Cyclopropane with mask	For more extensive procedures
	3 Ethylene or nitrous oxide	For procedures not requiring relaxation
	4 Basal with nitrous oxide or ethylene	For apprehensive subjects
	5 Ethylene or nitrous oxide followed by ether	For extensive procedures in which 2 cannot be used
	6 Spinal	A major anesthetic for a minor procedure
	Children	
	1 Open drop ether	
	2 Cyclopropane	
43 Wall—Inguinal or Femoral Hernia		
Clinical 1 Usually in active subjects but may occur at any age 2 Are elective except when strangulation is present *Surgical* 1 Usually not prolonged 2 Relaxation of moderate degree required 3 Peritoneum and abdominal viscera are manipulated *Anesthetic* 1 Traction reflexes from cord cause laryngeal spasm 2 Airway easily maintained except in obese subjects	1 Spinal	Suitable for most patients in good health
	2 Cyclopropane	Suitable for apprehensive subjects who object to spinal
	3 Nitrous oxide pentothal basal with muscle relaxant	Desirable but depression in postoperative period may follow Traction reflexes may induce spasm
	4 Nitrous oxide or ethylene followed by ether	When 1 2 and 3 are contraindicated
	5 Local	In poor risk subjects Traction reflexes on cord and peritoneum may cause nausea and vomiting
	Children	
	1 Cyclopropane—ether by closed system	
	2 Open drop ether	When closed system is not available

TABLE II—(*continued*)

Problems Encountered	Choices	Remarks
50 Vaginal Examination		
Surgical		
1 Brief	1 Nitrous oxide	Pleasant—no nausea
2 No relaxation needed	2 Ethylene	Somewhat nauseating to some patients
3 May be ambulatory	3 Cyclopropane	Nausea and vomiting which may follow it for such a brief procedure is objectionable
Anesthetic		
1 Manipulation may cause reflex effect on respiration	4 Pentothal—nitrous oxide	Laryngeal spasm may occur from stimulation
51 Cervix—Dilatation and Curettage Removal of Polyps, Conization, Biopsy etc.		
Clinical		
1 Patient may be septic, anemic, on verge of shock if post abortal	1 Nitrous oxide	Pleasant rapid acting no nausea
2 May be in any age group	2 Ethylene	Somewhat nauseating to some patients Rapid acting
Surgical	3 Cyclopropane	Desirable except nausea and vomiting may follow
1 Brief		
2 No relaxation required	4 Nitrous oxide—pentothal	Satisfactory
3 Performed in lithotomy position	5 Local with heavy sedation	Satisfactory in cooperative patient
4 Blood loss may occur		
5 Uterus may be perforated	6 Spinal	A major anesthetic for a minor procedure in most cases
6 Cautery may be used		
Anesthetic	7 Caudal	Satisfactory procedure if high
Airway easily maintained		
52 Uterus—Vaginal Hysterectomy		
Clinical		
1 Usually performed in middle aged and older females	1 Spinal	Ideal but must extend to T 10
2 May be performed in patients not able to stand more extensive surgery	2 Cyclopropane with or with out muscle relaxant	Ideal when general anesthesia is desired Rapid recovery
	3 Ethylene or nitrous oxide ether	Suitable if 1 and 2 are contra indicated
Surgical	4 Pentothal nitrous oxide with muscle relaxant	Traction reflexes cause laryn geal spasm Respiratory de pression occurs
1 Traction on pelvic vicera		
2 Peritoneal cavity entered		
3 Usually placed in lithotomy position	5 Caudal	Pelvic peritoneum not anes thetized Abdominal discom fort follows
4 Technical difficulties may necessitate use of suprapelvic approach in addition to perineal		
5 Moderate relaxation required to avoid bearing down and pushing of abdomi nal contents outward	6 Pentothal alone	Not satisfactory Large quan tities required
Anesthetic		
1 Traction may cause reflexes hypoten sion and bradycardia		
2 Airway maintained easily except in obese patients		
3 Moderately deep anesthesia required		
53 Vagina—Incision and Drainage of Pelvic Abscess		
Clinical		
1 Sep is present	1 Cyclopropane	Rapid induction and recovery
Surgical	2 Nitrous oxide or ethylene followed by ether	Use when cyclopropane is contraindicated
1 Lithotomy position required	3 Pentothal nitrous oxide	Suitable but spasm may oc cur
2 Performed trans vaginally		
3 Usually brief	4 Open drop vinyl ether	Useful in brief and in children
4 Circulatory collapse may follow drain age	5 Spinal	Septic condition may preclude its use
Anesthetic		
1 Anesthetist has access to head Air way maintained with ease except in obese patients		

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
	PERINEUM	
47 Genitalia (Male)—Orchidectomy Hydrocelectomy Vasectomy and Other Operations on Genitalia		
Clinical		
1 Adults most often 2 Usually good risks	1 Spinal	Suitable for extensive procedures
Surgical	2 Cyclopropane	Useful for apprehensive non cardiacs
1 Relaxation not needed 2 Patient is in supine position 3 May use cautery	3 Nitrous or ethylene and ether	When 1 and 2 are contraindicated
Anesthetic	4 Pentothal basal nitrous oxide	When cautery is used and spinal and local cannot be used
1 Traction reflexes may cause circulatory and respiratory changes	5 Local	For simple procedures or in extremely poor risks
	Children	
	1 Ether open drop	When closed system is not available
	2 Ether closed system.	If suitable apparatus is available
	3 Cyclopropane closed system	If suitable apparatus is available
48 Penis—Circumcision		
Clinical		
Elective in young ealthy males as a rule	1 Local	Usual procedure employed
	2 Cyclopropane	Rapid acting rapid recovery
Surgical	3 Spinal	A major anesthetic for a minor procedure
1 Brief 2 No relaxation required	4 Caudal	Only satisfactory when it is high Frenulum not blocked
Anesthetic	5 Pentothal alone or pentothal nitrous oxide	Priapism and laryngeal spasm may occur
1 Reflex stimulation may occur	*Children*	
	1 Cyclopropane	Suitable if satisfactory apparatus is available
	2 Nitrous oxide or ethylene followed by ether	Suitable if satisfactory apparatus is available
	3 Ether open drop	Suitable if satisfactory apparatus is not available
49 Genitalia—Female—Vaginoplasties—Perineal Repairs Cystocele Rectocele Perineorrhaphy and Other Operations on the Vulva Vagina & Cervix		
Clinical		
1 May be in any age group—usually middle age	1 Spinal	Abolishes reflexes
2 Are usually in good physical condition	2 Cyclopropane	Most satisfactory when general anesthesia is indicated
Surgical	3 Ethylene or nitrous and ether	Suitable when 1 and 2 cannot be used
1 Patient is placed in lithotomy position frequently (May be in Simms in some cases)	4 Pentothal or other basal and nitrous oxide	Laryngeal spasm and respiratory depression occur postoperatively
2 Profound relaxation not required	5 Local	For simple procedures of a minor nature
Anesthetic	6 Caudal	Usually not sufficiently extensive unless it is high
1 Reflexes may cause hypotension accompanied by bradycardia, and respiratory disturbances	*Children*	
	1 Cyclopropane 2 Ether by closed system 3 Ether by open drop	

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
36 Vertebral Column—Thoracic Laminectomy—Spinal Fusion Reduction of Fractures		
Clinical 1 Are usually performed for trauma disks, cord tumors tuberculosis and other afflictions of the cord 2 May have paralysis of lower part of body including respiratory muscles *Surgical* 1 Must be performed in prone position 2 Shock and blood loss common 3 May be long 4 Usually use electrocoagulation for hemostasis *Anesthetic* 1 Intratracheal tube necessary to maintain airway 2 May require artificial respiration throughout procedure 3 May be unable to flex or extend head—interferes with intubation	1 Pentothal basal and nitrous oxide intratracheally (With cyclopropane to do intubation) 2 Cyclopropane intratracheally 3 Nitrous oxide or ethylene followed by ether oxygen intratracheally 4 Local or regional epidural *Children* 1 Same as adults	Not flammable except in beginning if cyclopropane is used When coagulation current is not used When 1 and 2 cannot be used Not recommended Patient experiences discomfort
37 Laminectomy (Lumbar) Spinal Fusions Operations on Sacrum Excision of Coccyx etc.		
Clinical 1 Are performed for othopedic, neurologic traumatic or for infections. 2 May have paraplegia sensory changes or other neurologic disturbances. 3 May have decubitus ulcers *Surgical* 1 Are performed in prone position 2 May be followed by shock and blood loss 3 Electrocoagulation may be required 4 May be long *Anesthetic* 1 Intratracheal tube is necessary to maintain airway 2 May require artificial respiration throughout procedure 3 May be unable to flex or extend head—interferes with intubation 4 Operation may outlast block if spinal is used	1 Spinal 2 Cyclopropane induction followed by nitrous oxide intratracheally and basal of pentothal 3 Cyclopropane intratracheally 4 Nitrous oxide or ethylene with ether intratracheally 5 Local nerve blocks and peridural *Children* 1 Cyclopropane followed by nitrous oxide intratracheally 2 Cyclopropane intratracheally 3 Nitrous oxide or ethylene with ether intratracheally *Less Desirable or Contraindicated* 4 Open ether	Ideal when neurologic diseases or psychic state does not preclude its use When cautery is used Flammable May be used when no fire hazard exists When 1 and 3 are not suitable Not easily and adequately maintained Psychic trauma pronounced Spinal not suitable Spinal not suitable Spinal not suitable Airway not maintained adequately
38 Vertebral Column—Sacrum—Excision of Pilonidal Sinus		
Clinical 1 Subjects usually are young and vigorous *Surgical* 1 Prone position is required 2 Infection may be present at site of lesion *Anesthetic* 1 Airway is difficult to maintain without endotracheal tube 2 Positional changes cause changes in blood pressure	1 Spinal 2 Cyclopropane intratracheally 3 Ether intratracheally 4 Nitrous oxide and basal pentothal	Ideal unless infection is too near site of lumbar puncture Rapid induction and recovery assured Suitable if 1 or 2 are contraindicated Respiratory depression may occur Undesirable with patient in prone position

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
RECTAL SURGERY		
54 Hemorrhoidectomy Excision of Anal Fissure Repairs of Prolapse Removal of Sinus Tracts		
Clinical 1 Patients are adults most often 2 Are usually good risk subjects 3 Anemia may be present in protracted cases of internal hemorrhoids 4 Fistulous tracts may be associated with tuberculosis infections *Surgical* 1 Relaxation must be extreme 2 Lithotomy position used by some Prone jackknife position by others 3 Cautery may be used 4 Are usually of short or moderate duration *Anesthetic* 1 Airway difficult to maintain in prone position Use intratracheal tube 2 Hypoventilation accentuated by prone position 3 Deep anesthesia required to relax sphincters 4 Laryngeal spasm develops reflexly during general anesthesia	1 Spinal (saddle) with long lasting drug 2 Caudal 3 Transacral 4 Intratracheal cyclopropane or nitrous oxide ether 5 Basal of pentothal intratracheal nitrous oxide and muscle relaxant *Less Desirable* 6 Local 7 Open drop ether 8 Basal narcosis alone	1 Provides desired relaxation and sustained analgesia in immediate postoperative period 2 Excellent relaxation Post spinal headache avoided 3 When caudal canal is inaccessible and spinal is not desired 4 Flammable Relaxation not always satisfactory 5 When cautery is used Not desirable in prone position because of inadequate ventilation 6 Edema distorts tissues Satisfactory anesthesia not always obtained 7 Deep anesthesia required for relaxation 8 Reflexes not abolished Relaxation inadequate Airway not under control in prone position

EXTREMITIES BONES JOINTS		
55 Vertebral Column—Cervical Laminectomy Spinal Fusion Reduction of Fractures etc		
Clinical 1 Are usually performed for trauma disks cord tumors tuberculosis and other afflictions of cord 2 May have paralysis or other neurologic lesions 3 May have paralysis of muscles of respiration *Surgical* 1 Must be performed in prone position 2 Shock and blood loss not uncommon 3 May be long 4 Usually use electrocoagulation for hemostasis *Anesthetic* 1 Intratracheal tube necessary to maintain airway 2 May require artificial respiration throughout procedure 3 May be unable to flex or extend head—interferes with intubation	1 Basal thiopental nitrous oxide intratracheally with cyclopropane to do intubation 2 Cyclopropane intratracheally 3 Nitrous oxide or ethylene followed by ether—oxygen intratracheally 4 Local or nerve blocks *Not Recommended* 5 Any type of anesthesia without intratracheal catheter *Children* 1 Same as for adults	Not flammable except in beginning May be used when coagulation current is not used When 1 and 2 cannot be used or are not desired Not satisfactory Patient experiences discomfort

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
62 Thigh and Hip—Osteotomy Insertion of Pins—Reduction of Fractures Muscle and Nerve Operations Bone Grafts		
Clinical		
1 Subjects are often elderly, particularly those with fractured hips	1 Spinal	For healthy subjects without contraindication to spinal anesthesia
Surgical	2 Cyclopropane	Suitable if 1 is not suitable or contraindicated
1 May be long and shocking		
2 Require considerable relaxation	3 Nitrous oxide—pentothal	Not flammable Use when 1 and 2 cannot
3 May require tourniquet		
4 Casts may be applied at conclusion of operation	4 Nitrous oxide or ethylene followed by ether	To be used when 1 2 and 3 cannot
5 May use electrical saws and X Ray equipment	5 Local	For brief procedures of simple nature or extremely poor risk subjects
Anesthetic		
1 Patient is in supine position Airway is accessible	*Children*	
	1 Cyclopropane	
	2 Nitrous oxide ether	
	3 Vinyl ether followed by open ether	If closed system is not available
63 Knee and Leg		
Clinical		
1 May be of varied age group or risk	1 Spinal	For healthy subjects without contraindication to spinal
Surgical	2 Cyclopropane	Suitable if 1 is not suitable
1 May be extensive and long	3 Nitrous oxide—pentothal	Not flammable Use when 1 and 2 cannot
2 Relaxation required		
3 May be shocking	4 Nitrous oxide or ethylene followed by ether	To be used when 1, 2 and 3 cannot.
4 X Ray and electric saw used		
Anesthetic	5 Local	For brief procedures of simple nature or for extremely poor risk subjects
1 Patient is in the supine position Air way is accessible		
AUTONOMIC NERVOUS SYSTEM		
64 Sympathectomy—Transthoracic and Lumbar		
Clinical		
1 Patients usually have some systemic illness (diabetes hypertension arteriosclerosis etc.)	1 Cyclopropane ether with pentothal induction	Rapid acting easily controlled depth of anesthesia
2 Are usually in upper age group	2 Nitrous oxide or ethylene ether with pentothal induction	When use of vasopressors is contemplated
Surgical		
1 Require thoracic approach	3 Nitrous oxide pentothal	When cautery is to be used
2 Patient must be on side	*Not Desired*	
Anesthetic	4 Spinal	Anesthesia required is too extensive
1 May require controlled respiration—intubate	5 Pentothal alone	Surgical procedure extensive
2 Blood pressure may be very labile	6 Local	
65 Lumbar Sympathectomy		
Clinical		
1 Usually have some systemic disease (diabetes hypertension etc)	1 Cyclopropane ether with pentothal induction	Labile—rapid acting Rapid recovery May further eliminate a high blood pressure
Surgical		
1 Require lumbar approach	2 Nitrous oxide or ethylene and ether	When vasopressors are needed
2 Require relaxation		
3 In semiprone position	3 Spinal or peridural	Relaxation excellent May cause severe fall in blood pressure
Anesthetic		
1 Blood pressure labile	4 Nitrous oxide—pentothal and muscle relaxant	When general anesthesia is required with a cautery
	Not Desired	
	5 Local	
	6 Pentothal alone	
	7 Lumbar block	

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
59 Upper—Arm—Extremity Upper—Reduction of Fractures Amputations Joint Explorations Osteotomies Nerve Suture		
Clinical		
1 May be in any age group	1 Brachial plexus block.	Suitable for forearm Upper arm and axilla not anesthetized
Surgical		
1 Relaxation needed	1 Cyclopropane	Most satisfactory Rapid acting rapid recovery
1 Tourniquet may be used painful with block anesthesia	2 Nitrous oxide with basal of pentothal	When cautery or X Rays are used
3 May be long		
4 Usually performed in supine but may be done in lateral position	3 Ethylene or nitrous oxide followed by ether	When 1 and 2 cannot be used
5 X Ray apparatus may be used	4 Local	For minor procedures only
6 May be shocking and accompanied by blood loss	*Children*	
Anesthetic	1 Vinethene	For minor procedures
	2 Vinethene and ether	When suitable closed system is not available
1 Anesthetist may be in operators way (shoulder) Endotracheal tube required	3 Cyclopropane	When closed system is available
	4 Nitrous oxide or ethylene ether	When closed system is available
60 Forearm and Hand—Tendon Repairs Incision and Drainage Reduction of Fractures Excision of Nodes Masses etc.		
Clinical		
May be in any age group	1 Cyclopropane	Suitable if operation outlasts the block
Surgical		
1 May be long and tedious	2 Brachial plexus block	Of equal preference to 1 depending upon patient.
2 Relaxation required for larger muscles		
3 Tourniquet may be required	3 Nitrous oxide and pentothal	Of equal preference to 1 and 2 depending upon patient.
Anesthetic		
1 Airway maintained with ease—patient in supine position	4 Nitrous oxide or ethylene with ether	Only if 1 2 or 3 are not desired
2 Surgeon and anesthetist do not compete for operative field Endotracheal tube not necessary	*Children*	
	1 Cyclopropane	Suitable if closed system is available
	2 Ethylene or nitrous oxide —ether	
	3 Vinyl ether followed by ethyl ether	When closed system is not available
61 Upper Hand—Digits—Incision and Drainage—Other Minor Procedures		
Clinical		
1 May be in any age group	1 Cyclopropane	Rapid induction and recovery
Surgical	2 Ethylene	Suitable in well premedicated patients
1 Little or no relaxation required	3 Nitrous oxide pentothal	Suitable in well premedicated patients
2 Are usually short without shock or blood loss		
3 Patient may be ambulatory	4 Brachial plexus block	Satisfactory in non apprehensive subjects
4 Sepsis may be present	5 Vinyl ether—nitrous oxide or ethylene followed by ether	For short procedures
Anesthetic		
Anesthetist has control of airway	6 Local infiltration or digital block	For simple procedures without peripheral vascular disease or infection
	Children	
	1 Vinethene	For brief simple procedures
	2 Cyclopropane	
	3 Vinethene and ether	When closed system is not available

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
	OBSTETRICS	
69 Normal Delivery—Primipara		
Clinical 1 Is young and in good health with few exceptions 2 May have slight decrease in hemoglobin *Obstetrical* 1 Labor may be long and require analgesia 2 May need episiotomy 3 May need forceps 4 May have posterior or other less common presentation *Anesthetic* 1 May have eaten 2 May have no premedication 3 Develop stridor when head passes over perineum	1 Cyclopropane	Ideal in uncomplicated cases Baby may be depressed
	2 Ethylene	Cannot always be given without anoxia
	3 Nitrous oxide or ethylene with ether	Anoxia obviated but nausea and vomiting objectionable
	4 Nitrous or ethylene with vinyl ether	Salivation common unless scopolamine is given
	5 Nitrous oxide with trichlorethylene	Tachypnea cardiac effects and vagal effects common
	6 Saddle block	Headache and blood pressure drops may follow May slow up labor increases incidence of instrumental deliveries
	7 Caudal block	Blood pressure drops failures common increased instrumental deliveries Labor slowed
	8 Pudendal block	Satisfactory for perineal pain does not relieve backache and visceral pain
	Less Desirable	
	9 Pentothal nitrous oxide	Depressed baby common
	10 Nitrous oxide—oxygen	Rarely can be given without anoxia
	11 Open drop ether	Nausea vomiting and depressed baby are common
	12 Trichlorethylene	Good for analgesia but not anesthesia
70 Multipara		
Clinical 1 Usually have been in shorter labor than primipara 2 Are women in child bearing age in good health Few if any abnormalities encountered 3 Two individuals to consider baby and mother *Obstetrical* 1 Usually do not require forceps 2 Usually do not require epesiotomy 3 Postpartum hemorrhage may occur 4 Oxytoxic drugs are used *Anesthetic* 1 May use narcotics barbiturates and other hypnotics during labor 2 May have eaten 3 May have anemia 4 May have elevated blood pressure	1 Cyclopropane	Ideal in uncomplicated cases Baby may be depressed if delivery is long
	2 Ethylene or nitrous oxide	Cannot always be given without anoxia
	3 Nitrous oxide or ethylene with ether	Anoxia obviated but nausea vomiting objectionable
	4 Nitrous oxide or ethylene with vinyl ether	Salivation common unless scopolamine is given Relaxation poor
	5 Nitrous oxide with trichlorethylene	Tachypnea cardiac and vagal effects encountered
	6 Saddle block	Post spinal headache and blood pressure drops may be encountered
	7 Caudal block	Blood pressure drops may occur Failures common Incidence of instrumental deliveries increased Labor slowed
	8 Pudendal block	Satisfactory for perineal pain does not relieve uterine and back pains
	9 Vinethene (open drop)	Suitable for short deliveries Salivation occurs
	10 Pentothal nitrous oxide	Depressed baby common unless period of use is less than few minutes
	11 Nitrous oxide—oxygen	Rarely can be given without anoxia
	12 Open drop ether	Nausea vomiting and depressed baby are objectionable features
	13 Trichlorethylene	Good for analgesia but not anesthesia

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
66 Stellate Ganglionectomy		
Clinical 1 Usually performed for vascular disease of head or extremity causalgia to relieve angina excess sweating status asthmaticus 2 Patients are usually adults *Surgical* 1 Operation is in neck area Anesthetist must be out of operative field 2 Pleura may be entered—pneumothorax possibility 3 Many vital structures in area—bleeding may occur 4 May be long and tedious *Anesthetic* 1 Airway difficult to control without endotracheal tube 2 Relaxation not needed Positive pressure may be needed if pleura is entered 3 Reflexes due to stimulation of structures in neck (carotid sinus vagus trachea) may arise Atropine needed	1 Cyclopropane intratracheally	Rapid acting—rapid recovery
	2 Cyclopropane ethylene or nitrous oxide followed by ether	Suitable when #1 cannot be used
	3 Nitrous oxide—pentothal with intratracheal tube	Not flammable suitable when cautery or x ray unit is to be used
	Not Desirable	
	5 Local	Not sufficiently extensive or may not last long enough for the purpose
	6 Cervical plexus block	Not extensive for purposes
	7 Pentothal alone	No control of airway Large doses needed
	8 Open drop ether without endotracheal tube	Control of airway impossible
	VASCULAR SURGERY	
67 Cerebral Angiogram		
Clinical 1 May have neurological lesion with increased intracranial pressure 2 May be comatose (see intracranial) *Surgical* 1 Operative site is neck Anesthetist must be out of operative field 2 Vessel not easily identified without direct exposure *Anesthetic* 1 Airway difficult to maintain Requires intubation 2 X ray needed—*flammable agents can*not be used Convulsions and other neurological manifestations occur during or before procedure begins 3 Disturbances of vascular and respiratory system may occur as dye is injected	1 Local	Not always adaptable to patient Exploration for artery not always possible
	2 Pentothal—nitrous oxide intratracheally with topical	Not flammable
	3 Cyclopropane	Ideal but is flammable
	4 Ether preceded by nitrous oxide or ethylene	Satisfactory but is flammable
	5 Vinethene	Operation too long Flammable—secretions copious
68 Renal Angiogram		
Clinical 1 Has suspected renal lesion 2 May be chronically ill *Surgical* 1 Performed in prone position 2 Spasm of artery and pain at time dye is introduced *Anesthetic* 1 Airway difficult to maintain without intratracheal catheter 2 Analgesia needed at time dye passes into vessel 3 X ray unit used—fire hazard 4 Procedure is a diagnostic one and relatively minor requiring major anesthetic	1 Pentothal nitrous oxide intratracheally (with relaxant to intubate)	Not flammable It is a major anesthetic procedure for minor diagnostic procedure
	2 Spinal anesthesia	Suitable but is major anesthetic for minor procedure
	Not Desirable	
	3 Local anesthesia	Does not relieve pain at time of injection
	4 Ether	Flammable
	5 Cyclopropane	Flammable
	6 Pentothal alone with no intratracheal tube	May asphyxiate from obstruction Airway not under control

TABLE II—(*continued*)

Problems Encountered	*Choices*	*Remarks*
74 Toxemia		
Clinical 1 May have edema	1 Local	Least innocuous but not always suitable
2 May have liver or renal failure or both	2 Ethylene—ether	Ether undesirable because of effect in metabolism and acid base balance
3 May have elevated blood pressure (diastolic) due to vasospasm 4 May have renal insufficiency	3 Cyclopropane	Suitable but may raise blood pressure
5 May have cardiac involvement 6 May have convulsions or other signs of C N S irritability	4 Ethylene	Anoxia—may not be potent enough for operative obstetrics
Obstetrical 1 May perform ceasarean section or delivery naturally or aided by forceps	5 Pentothal—nitrous oxide	May be used if delivery is rapid
2 Fetal distress may be present	6 Caudal	May cause fall in blood pressure Technically not always easily performed
3 May require heavy sedation to control convulsion	7 Spinal	Causes hypotension Patient awake and apprehensive
Anesthetic 1 Avoid obstruction (anoxia and CO_2 excess)	*Avoid* 8 Chloroform	Damages liver
2 Avoid pressor substances or drugs which elevate or markedly drop blood pressure	9 Trichlorethylene	Damages liver
3 Avoid drugs which effect kidney and liver	10 Vinyl ether	Not sufficiently potent May be hepatotoxic

TABLE III

DRUGS TO USE FOR OR DURING ANESTHESIA FOR THE MORE COMMONLY ENCOUNTERED CLINICAL CONDITIONS

Diseases	*Permissible Drugs*	*Drugs to Avoid*
Acute infections of upper respiratory tract	Cyclopropane, ethylene, nitrous oxide spinal, nerve block, local muscle relaxants	Ether ultra short acting barbiturates, chloroform, ethyl chloride avertin, paraldehyde
Acute infections of lower respiratory tract	Cyclopropane ethylene, nitrous oxide, spinal, nerve block, local	Ether vinyl ether, ultra short barbiturates, chloroform avertin, paraldehyde
Chronic respiratory tract infections with suppuration or diminished vital capacity	Cyclopropane, ether, ethylene nitrous oxide vinyl ether, spinal, local, muscle relaxants	Ultra short acting barbiturates narcotics high spinal, chloroform, paraldehyde
Myocardial disease	Ether, vinyl ether, ethylene, nitrous oxide pentothal low spinal, nerve blocks local, muscle relaxants	Cyclopropane, chloroform, ethyl chloride, high spinal, pentothal in large amounts, muscle relaxants in large amounts
Severe valvular disease	Ether, vinyl ether, ethylene, nitrous oxide pentothal, low spinal, nerve blocks local muscle relaxants	Cyclopropane chloroform ethyl chloride, high spinal, pentothal in large amounts muscle relaxants in large amounts
Hypotension due to hypovolemia	Cyclopropane vinyl ether, nitrous oxide, ethylene, local nerve block	Ether pentothal narcotics muscle relaxants chloroform spinal
Hypotension (essential)	Ether cyclopropane, nitrous oxide, ethylene, vinyl ether, local, nerve block.	Spinal muscle relaxants non volatile basal anesthetics narcotics

TABLE II—*(continued)*

Problems Encountered	*Choices*	*Remarks*
71 Forceps Deliveries		
		Same as for multipara except more profound anesthesia needed
72 Caesarean Section		
Clinical 1 May or may not be in labor 2 Have some obstetric complication such as (a) placenta praevia (b) disproportion (c) toxemia nephritis (d) prolonged labor due to obstetrical difficulty (e) ruptured uterus 3 May be in shock from some obstetric complication or have hypertension	1 Local	Not always adequate
	2 Cyclopropane	Rapid induction and recovery—suitable most of time
	3 Spinal	Good for the newborn Blood pressure drop severe and more difficult to control
	4 Cyclopropane ethylene or nitrous oxide followed by ether	Has all disagreeable features of ether Prolonged somnolence for baby in long cases
	5 Pentothal and nitrous oxide	Depresses newborn
Obstetrical 1 Relaxation of some degree required The procedure is an abdominal operation 2 Usually placed in head down position 3 There may be blood loss 4 There may be fetal distress	*Not Suitable*	
	6 Caudal block	Extent of block not sufficient for purpose
	7 Saddle block	Extent of block not sufficient for purpose
	8 Ethylene alone	Not of sufficient potency
	9 Nitrous oxide alone	Not of sufficient potency
	10 Muscle relaxants	Not needed Also pass through placenta to baby
Anesthetic 1 Patient may have eaten—aspiration 2 Usually cannot be sedated until baby is born 3 Ventilation impaired due to abdominal mass		
73 Versions		
Clinical 1 Usually performed in difficult and complicated situations 2 Patient may have been in labor long time and be dehydrated or in shock 3 May be multipara or primipara	1 Ether—preceded by cyclopropane nitrous oxide or ethylene	Only available agent which relaxes smooth muscle which is safe
	2 Chloroform	Relaxes uterus but may depress heart.
Obstetrical 1 Relaxation of uterus required 2 Fetal distress may be present 3 May use uterine relaxants such as epinephrine	*Not Suitable*	
	1 Spinal anesthesia	None of the following relax uterine musculature
	2 Saddle block	
	3 Caudal block	
	4 Pudendal block	
Anesthetic 1 Anesthesia must be deep to relax uterus 2 Relaxation may take some time to accomplish May have eaten 3 Shock or hemorrhage may follow	5 Muscle relaxants	
	6 Cyclopropane (alone)	
	7 Ethylene or nitrous oxide alone or with pentothal	
	8 Vinethene	

PRELIMINARY EXAMINATION OF THE PATIENT

The patient should be interviewed and his chart examined before the operation

The following data should be noted on the anesthetic record (see Figs 1 and 2)

Data	*Reasons*
1 *Nativity*	Frequently it is an index to emotional status and yields data which influence choice of agent or technique
2 *Weight of patient*	It may be an index to basal metabolic rate and yield data to be considered in determining type and dose of premedication
3 *History of previous anesthesias* *Note* drugs employed, type, duration, complications and operation performed	Previous difficulties or errors may be avoided
4 *Risk*, according to classification	This influences both choice of anesthetic agent and technique of administration
5 *Body Temperature*	This may be an indication of the metabolic rate and serve as a guide to selection of premedication
6 *Laboratory Data*	
a Hemoglobin content and erythrocyte count *Note* anemias	They are the only reliable indications of the oxygen carrying power of the blood
b Leukocyte count and differential	They indicate presence of infection, sepsis, fever, or toxemia and yield data regarding premedication and choice of agent
c Roentgenograms *Note particularly* views of neck and thorax which show obstruction or distortions of airway	Advance information regarding abnormalities of airway and other parts of the respiratory tract is desirable
d Serological test	Special precautions to avoid infection may be necessary if patient has syphilis
e Urine analysis	Abnormal constituents indicate metabolic disturbances which may be enhanced by anesthesia

TABLE III—(*continued*)

Diseases	*Permissible Drugs*	*Drugs to Avoid*
Hypertension (essential)	Ether, cyclopropane nitrous oxide, pentothal spinal, local muscle relaxants	Vasopressors high spinal
Anemia both primary and secondary and blood dyscrasias causing anemia	Ether cyclopropane, ethylene, nitrous oxide nerve blocks, local, non volatile agents in small amounts	Non volatile drugs in large amounts spinal chloroform, muscle relaxants ethyl chloride
Acidosis dehydration	Cyclopropane vinyl ether nitrous oxide, ethylene spinal nerve blocks local	Ether chloroform muscle relaxants, non volatile drugs narcotics
Diabetes controlled	Cyclopropane, vinethene, ethylene nitrous oxide spinal local nerve block muscle relaxants	Avertin pentothal ether chloroform ethyl chloride
Liver insufficiency jaundice	Cyclopropane ethylene nitrous oxide pentothal, spinal local nerve block	Ether chloroform ethyl chloride vinethene, avertin muscle relaxants
Renal insufficiency	Cyclopropane ethylene nitrous oxide spinal local nerve block	Ether vinethene avertin chloroform ethyl chloride barbiturates muscle relaxants
Thyrotoxicosis	Ethylene nitrous oxide with heavy sedation of avertin pentothal or morphine, ether	Cyclopropane local nerve block chloroform, vinethene
Increased intra abdominal pressure due to tumors acites distension	Cyclopropane ether, ethylene nerve block local muscle relaxants	Spinal pentothal avertin chloroform ethyl chloride vinethene
Diseases of the heart	Ether ethylene nitrous oxide vinyl ether non volatile anesthetics local nerve blocks	Spinal narcotics
Increased intra cranial pressure	*Cyclopropane ether avertin* pentothal local nerve block muscle relaxants	*Morphine nitrous oxide or* ethylene with anoxia
Mental diseases	Ether, cyclopropane avertin ethylene pentothal nitrous oxide muscle relaxants	Local spinal nerve block.
Alcoholism (acute)	Ether cyclopropane ethylene nitrous oxide muscle relaxants	Spinal local nerve block avertin pentothal
Alcoholism (chronic)	Spinal local nerve block	Inhalation intravenous and rectal anesthesia

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Adriani, John The Pharmacology of Anesthetic Drugs Charles C Thomas Springfield, Ill, 3rd Ed, 1953

Adriani John Selection of Anesthesia Charles C Thomas, Springfield, Ill, 1955

mechanism Hypotension or hypertension should be correlated with changes in the heart and kidneys	drugs or procedures which decrease cardiac output (spinal anesthesia, deep anesthesia, avertin, and intravenous barbiturates) may aggravate abnormalities and should therefore be avoided
e Peripheral vascular disease and peripheral circulatory failure	Drugs which cause vasoconstriction, especially in infiltration anesthesia may not be desirable
f Abnormalities of cellular elements of blood (dyscrasias) disturbances of clotting mechanism, platelets, etc	Special care should be exercised to avoid anoxemia, or carbon dioxide excess Drugs which cause respiratory depression should be avoided
9 *Metabolism*	
a Basal metabolic rate	This may be an index to oxygen requirement and carbon dioxide output during maintenance of anesthesia
b Diabetes, acidosis, or dehydration *Note* fluid balance	Drugs which enhance acidosis (such as ether, chloroform, or carbon dioxide excess) are undesirable and should be avoided
c Diseases of the endocrine glands Correlate with metabolic rate	They may influence choice of pre medication if metabolic rate is altered
d Diseases due to vitamin deficiencies	They may be accompanied by biochemical disturbances which may influence selection of agent or technique
10 *Gastro-Intestinal System*	
a Nausea and emesis *Note* cause, frequency, and nature of vomitus	Rapid induction is necessary if present Precautions to avoid aspiration are to be observed
b Intra abdominal injuries *Note* perforation of a hollow viscus, the presence of shock, or abdominal rigidity	These influence selection of agent Deep anesthesia may be necessary to overcome abdominal rigidity
c Contour of abdomen *Note* any distension, gastric dilatation, or intestinal obstruction Investigate fluid balance Note presence of ascites or large tumor masses	Gastric or intestinal decompression and drainage may be necessary before anesthesia to remove gas and fluid if intestinal obstruction is present
d Liver disease or decreased	Ether, anoxia, chloroform, and

7 *Respiratory System*

a Rate, depth, and type of movements The presence of dyspnoea, hyperpnoea, Cheyne-Stokes respiration, or other abnormalities is significant	Carbon dioxide excess, anoxia, or respiratory depression should be scrupulously avoided if abnormalities exist
b Minute volume exchange *Note* the extent of any decrease	If decreased, drugs which cause depression of respiration are contraindicated
c Vital capacity *Note* any decrease	Anoxemia, carbon dioxide excess, or depression of respiration should be avoided if decreased
d Infections of upper or lower respiratory tract (acute or chronic)	Irritating drugs such as ether, chloroform, vinethene, ethyl chloride are not desirable or are contraindicated
e Suppurative processes *Note* history of abscess, bronchiectasis, bronchitis, etc. *Note* character, amount, and frequency of expectorations or the presence of bronchorrhea or purulent material	Tracheal and bronchial suction or even bronchoscopy may be desirable or necessary before and during and immediately after anesthesia
f Airway *Note* nasopharyngeal abnormalities, bronchial or tracheal obstruction, or the presence of edema or neoplasms anywhere in respiratory tract	Preparations for intratracheal intubation, tracheotomy, or positive pressure anesthesia and suction (see Part II) may be necessary if abnormalities exist.

8 *Circulatory System*

a Myocardial disease *Note* any change in size of the heart and state of myocardium	Drugs which increase cardiac irritability (such as chloroform, cyclopropane, and ethyl chloride), or techniques which decrease cardiac output (spinal anesthesia) are contraindicated
b Valvular diseases *Note* type and etiology and state of compensation	The forementioned objections apply also to valvular disease
c. Disturbances of rhythm *Note* type, severity and persistence of the arrythmia. Record E K G changes	Epinephrine, cyclopropane, chloroform and other drugs which increase cardiac irritability are objectionable.
d Disturbances of the vasomotor	Carbon dioxide excess, anoxia, and

	doses may be required for premedication if patient is not "cured"
g Neuritis, palsies, spasticity of muscles, or other skeletal defects	Regional anesthesia may be undesirable if pathological changes are present in nerves and muscles
h Medication being received	Drugs such as digitalis may influence choice Drugs such as cortisone must be continued

PREPARATION OF PATIENT FOR ELECTIVE SURGERY

1 Administer a barbiturate (or opium alkaloid if patient has pain) the evening before to assure a night's rest Also administer a sedative drug *in the morning* if operation is to be performed late in the forenoon or afternoon
2 Request enema, and other preparations *the evening prior* to operation for all elective surgery
3 Omit breakfast and fluids If operation is to be performed in the afternoon, allow fluids in the morning Discontinue everything at least four or five hours prior to anesthesia
4 Order premedication for type of anesthesia selected (see premedication)
5 Examine the patient's chart and be certain all necessary laboratory data such as urine analysis, hematological studies, and examination of heart and lungs, etc , have been performed and are recorded
6 Examine the patient for recently acquired complications such as "cold," infections, etc , particularly if a time interval has elapsed between previous examinations

PRE ANESTHETIC MEDICATION

(A) General Considerations of Premedication

1 *Purpose of Premedication* There are five chief reasons for administering premedication before anesthesia
   a Psychic sedation This relieves apprehension and to a certain extent decreases length of second stage of inhalation anesthesia
   b To secure an additive effect between two depressant drugs of low analgesic or anesthetic potency Example Pentothal or morphine combined with nitrous oxide
   c Reduction of metabolic rate and decrease of reflex irritability It decreases oxygen requirement and facilitates induction with N_2O and similar agents It reduces quantity of anesthetic drug necessary for narcosis in many instances
   d Minimizing or abolishing secretion of saliva and mucous This prevents respiratory obstruction during anesthesia and respiratory complications after operation

function, jaundice	certain non-volatile drugs disturb liver function
e Colonic inflammations, irritations or neoplasms	Rectally administered drugs may be undesirable and cause colitis or proctitis Drug may not be ab sorbed through diseased mucosa
f Time of last meal or fluid	Postponement of operation if food or fluids were recently ingested is desirable and advisable Danger of aspiration is great if liquid or solid food is regurgitated
11 *Genito urinary System*	
a Renal disease — nephritis, nephrosis, tuberculosis	Irritating agents such as ether, chloroform, or vinethene should be avoided
b Obstruction to urine flow, pyelitis, lithiasis	Acidosis may be present and be ag gravated by certain drugs
c N P N , blood urea, the presence of anuria, oliguria, or uremia	Anoxemia, carbon dioxide excess aggravate the acidosis which may be present in renal failure
12 *Central Nervous System*	
a Intracranial lesions, neoplasms, or cerebral injury Diseases of the spinal cord *Note* especially increases in intracranial pres sure	Anoxemia, carbon dioxide excess, and depressant drugs (such as morphine) may cause an increase in intracranial pressure Depressed respiration or apnoea and circula tory disturbances accompany in creased pressure
b Infections—syphilis, meningitis, poliomyelitis, myelitis, or encephalitis	Intrathecal injections of local an esthetic drugs are contraindicated
c Mental state *Note* psychosis, neurosis and whether or not patient is cooperative	Regional anesthesia may not be advised or large doses of preanes thetic sedation may be required to secure cooperation
d Eyes—size, reaction, and ab normalities of pupils	They are important for future ref erence in determining depth of narcosis
e Convulsions *Elicit* history and note cause and type	Anoxia or carbon dioxide excess may enhance epilepsy or other cor tical irritations
f Drug addiction or habituation *Note* whether due to alcohol or opium alkaloids	General anesthesia in alcoholic ad dicts is frequently accompanied by a severe prolonged excitement pe riod Opiates for "cured" opium addicts are not desirable or large

dose gr 1½ administered simultaneously with atropine or scopolamine in place of morphine in techniques described below

f Methadon Synthetic narcotic possessing same analgesic effects as morphine but less hypnotic and tranquilizing effect Used when morphine cannot be used Less effective than morphine

g Dromoran Synthetic narcotic chemically related to morphine, but with a less tranquilizing and hypnotic effect

h Barbiturates Useful for psychic sedation Depress the cortex and lower centers but have little effect on the metabolic rate Not satisfactory as substitute for opium derivatives but may be used in conjunction with them *Barbiturates produce amnesia, but no analgesia*

i Paraldehyde Usually employed as a sedative for chronic alcoholic addicts (see rectal anesthesia)

j Atropine Diminishes secretions by paralyzing parasympathetic nerve endings Stimulates cortex and medullary centers Paralyzes vagal nerve endings

k. Scopolamine (hyoscine) Diminishes secretions by paralyzing parasympathetic nerve endings Depresses cortex and produces amnesia. Enhances cortical depression of morphine when used with morphine Possesses a more pronounced effect on secretions than atropine Does not depress respiration *Is not an analgesic*

l. l hyoscyamine (Bellafolline) Diminishes secretions by paralizing parasympathetic nerve endings More potent than atropine Causes less side actions

m. Avertin Administered to produce a basal narcosis in apprehensive subjects (see rectal anesthesia)

n. Vasopressor drugs Employed to elevate blood pressure in "primary shock." Epinephrine, ephedrine, neosynephrine are the most prominent (see regional anesthesia)

o Cardiac depressants Drugs which decrease cardiac irritability such as quinidine, procaine amide and procaine are administered prophylactically to decrease arrhythmias

(B) Technique of Premedication for Various Types of Anesthesia

1 *Inhalation Anesthesia* Adults considered to be *average cases*

a Administer a therapeutic dose of a barbiturate (seconal or pentobarbital) or other sedative drug the evening previous to operation

b Administer (1) morphine sulphate gr 1/4, scopolamine hydrobromide gr 1/100 (ratio of 25 1) subcutaneously, 1 to 1½ hours prior to induction of anesthesia, or (2) morphine sulphate gr 1/4 subcutaneously atropine sulphate gr 1/100 (in a ratio of 25 1) 1 to 1½ hours before induction of anesthesia.

e Prophylaxis to avoid anticipated undesirable physiological and pharmacological effects produced by certain drugs or procedures
(1) Counteracts hypotension in spinal anesthesia (vasopressors)
(2) Decreases vagal effects accompanying anesthesia with pentothal, cyclopropane, chloroform, and other drugs (atropine)
(3) Minimizes or antagonizes toxic effects of local anesthetic drugs (barbiturates)
(4) Reduces cardiac irritability (procaine amide)

2 *Drugs Commonly Employed for Premedication*

a For psychic sedation
  a Alkaloids derived from opium and synthetic narcotics
  b Barbiturates and related amides
  c Basal narcotics—avertin, trichlorethanol, paraldehyde, etc
b For minimizing secretions
  a Parasympathetic depressants, notably atropine or scopolamine
c For reducing metabolic rate
  a Opium alkaloids
  b Avertin or barbiturates in large doses
d For prophylaxis
  a Vasopressor drugs
  b Parasympathetic depressants
  c Barbiturates
  d Drugs used to decrease cardiac irritability

3 *Evaluation of Available Drugs*

a Morphine Most widely employed because it most satisfactorily performs two of the above functions Morphine both reduces metabolic rate and produces psychic sedation
b Dilaudid (Dihydromorphinone) A synthetic drug derived from morphine possessing 8 to 10 times the potency of morphine Administer 1/8 to 1/10 of a comparable amount of morphine
c Codeine Infrequently employed for premedication except as a substitute for morphine for children Possesses approximately 1/4 the potency of morphine
d Pantopon Aqueous solution of the hydrochlorides of purified opium (10% solution) Contains morphine Possesses the same action as morphine 1/3 grain is the equivalent of 1/4 grain of morphine
e Demerol Synthetic substance derived from pyridine possessing a mild sedative action and analgesic action greater than codeine but less than that of morphine In addition it possesses an atropine like action Employed as a substitute for morphine and related compounds when these are not tolerated or are contraindicated Average

m Highly apprehensive or mentally disturbed patients Use basal narcosis with an ultra short acting barbiturate such as pentothal or short acting barbiturate (seconal or nembutal) intravenously Avertin may be used rectally For infants pentothal rectally

3 *Regional Anesthesia*

a Spinal anesthesia

(1) Administer a mixture of morphine and scopolamine in same quantities and proportion and with same technique as for inhalation anesthesia Required for psychic sedation to insure a cooperative patient Also necessary if anesthesia is unsatisfactory and must be supplemented by general anesthesia

(2) Administer a barbiturate, preferably of short acting type, such as amytal, nembutal, seconal, or similar drug, in therapeutic doses orally 1 to 1½ hours prior to operation Barbiturates antagonize toxic effect of local anesthetic drugs They also act in conjunction with morphine as psychic sedatives

(3) Administer a vasopressor drug (ephedrine gr 3/4 intramuscularly) Counteracts or prevents the hypotension which accompanies spinal anesthesia Administer routinely to subjects in whom hypotension is anticipated In uncomplicated cases, administer only when indicated after anesthesia has been induced (see spinal anesthesia)

b Nerve block, infiltration, and topical anesthesia
Employ same drugs and technique described for spinal anesthesia but omit ephedrine Same reasons as for spinal anesthesia

4 *Intravenous Anesthesia* (*Pentothal or Evipal*)

a Administer atropine or scopolamine gr 1/100 1 to 1½ hours prior to anesthesia Morphine sulfate 1/6 to 1/8 gr subcutaneously 1 to 1½ hours prior to anesthesia Belladonna alkaloids diminish vagal effects (laryngeal and bronchial spasm) Morphine is omitted by many anesthetists because it may enhance the respiratory depression produced by the barbiturate

5 *Rectal* (*Avertin*)

a Administer atropine or scopolamine gr 1/100 to 1/150 subcutaneously Morphine as recommended for inhalation anesthesia may be administered if desired, but is usually omitted Belladonna alkaloids minimize secretions produced by supplementary inhalation anesthesia necessary to complement narcosis Morphine may enhance respiratory depression produced by avertin

TABLE IV

EQUIVALENT DOSES OF OTHER DERIVATIVES OF OPIUM AND SYNTHETIC NARCOTICS COMPARED TO DOSE OF MORPHINE

	Grains	Milligrams
Morphine	1/4	15
Codeine	1	60
Dilaudid (Dihydromorphinone)	1/32	2
Demerol (Meperidine)	1 1/2	100
Methadon	1/4	15
Dromoran (Methyl Morphinan)	1/12	5
Nisentil (Alphaprodine)	2/3	40

2 *Inhalation Anesthesia Variations from the average*

a Aged subjects Administer morphine gr 1/6–1/8 and scopolamine or atropine gr 1/150–1/200 Metabolic rate decreases with age and less morphine is required (ratio 25 1)

b Young adults Administer morphine gr 1/4 and scopolamine gr 1/100 if metabolic rate is normal

c Patients in pain Administer full doses of morphine—gr 1/4–1/2 and scopolamine gr 1/100

d Cyclopropane anesthesia Decrease dose of morphine

e Fever Administer full therapeutic dose of morphine and scopolamine Metabolic rate is increased 7% for each degree (F) of fever

f Diabetes, acidosis, toxemias, etc Reduce morphine because it enhances acidosis Use 2/3 to 1/2 of the usual dose of morphine balanced with scopolamine in proportion of 25 to 1

g Intracranial diseases accompanied by increased intracranial pressure Omit morphine because it elevates intracranial pressure Administer atropine to minimize secretions if inhalation anesthesia is to be employed

h Hyperthyroidism or other conditions accompanied by elevated metabolic rate Administer morphine gr 1/4 and scopolamine gr 1/100 two hours prior to anesthesia Repeat using half to full dose one hour before anesthesia depending upon the effect first dose has produced

i Hypothyroidism or other conditions characterized by a reduced metabolic rate Decrease morphine 1/3 to 1/2 the usual adult dose and scopolamine in proportion of 25 to 1

j Emergency surgery Administer 2/3 to the full dose of morphine with scopolamine in proportion of 25 to 1 intravenously ten minutes prior to anesthesia Dilute drug well in saline and inject slowly (see intravenous anesthesia page 182)

k Obstetrics Administer atropine or scopolamine gr 1/100–1/150 but omit morphine or other alkaloids of opium

l Infants and children See section on pediatric anesthesia

Waters R. M A Study of Morphine, Scopolamine, and Atropine And Their Relation To Preoperative Medication And Pain Relief, Texas State J Med , 34, 294–301, August, 1938
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ANESTHESIA RECORDS

A record should be maintained throughout every operation regardless of the type of anesthesia administered Printed standard anesthesia records (Figs 1 and 2) are desirable Regardless of the type of chart employed, a good anesthesia record includes

1 Significant findings of preoperative examination
2 Details of conduct of anesthesia and a record of unusual events
3 Post operative course for a minimum of ten days in major surgery cases (The anesthetist may use his discretion in the length of the follow up period in cases of minor surgery)

Record this data during course of anesthesia

1 *Preliminary medication* Time, route of administration, dose and its effect
2 *Date* Month, day, and year
3 *Pulse* Rate and character Comment on abnormalities in space for remarks (Fig 1)
4 *Blood pressure* A record of the blood pressure should be maintained during every operative procedure
5 *Time* Induction and start and completion of the operation Termination of anesthesia Indicate whether the time is AM or PM
6 *Anesthetic agents and technique* Type, time administered, strength, etc Reason for selection of agent and technique Supplementary agents or techniques employed in the event that the primary agent is changed and reasons for the change
7 *Depth* Depth of inhalation anesthesia in planes of stage III Extent and duration of regional blocks Level of spinal anesthesia Mention drug dose, volume, diluent and site of injection
8 *Oxygen* Metabolic requirement and any additional amount
9 *Operation* Preoperative diagnosis, the proposed operation, the operation performed, and the post-operative diagnosis
10 *Members of the surgical team* Surgeon, assistants, anesthetists, and nurses
11 *Complications*
   a *During induction of anesthesia* Note and record the occurrence, duration, and intensity of any excitement period, spasm, nausea, emesis, cyanosis, anoxia, etc
   b *During maintenance of anesthesia* Note and record changes in quality of pulse, degree of muscular relaxation, the occurrence of respira-

6 *Common Errors in Premedication*

a *Premedication administered too early* Excess secretions and excitement follow Both result in a prolonged and difficult induction

b *Insufficient premedication* Same effects and results as too early administration

c *Premedication administered too late* Excess mucus and prolonged excitement follow Depression of respiration may often occur after anesthesia is established and confuse the anesthetist

d *Over premedication* Depression of respiration and circulation may occur Bradycardia, hypotension, and decreased amplitude and rate of respiration are commonly observed Relaxation is difficult to secure

e *Premedication omitted* Induction period prolonged, marked excitement, copious flow of mucus, laryngeal spasm, and poor relaxation may result Patient may be uncooperative if regional anesthesia is employed

Comment	*Reason*
1 Do not omit premedication	Induction and maintenance of anesthesia become difficult The patient suffers, the anesthetist is handicapped, and the operation is delayed
2 Do not order the drug to be administered "on call" or "on the stretcher"	Sufficient time must be allowed for drugs to exert their maximum effects
3 Do not administer premedication after anesthesia has been started	Its effect is required to facilitate induction of anesthesia The effects of morphine upon respiration may appear during the course of anesthesia and confuse the anesthetist
4 When morphine is administered for psychic sedation, scopolamine is preferred to atropine to minimize secretion of mucus	Scopolamine augments cortical effects of morphine and antogonizes medullary respiratory depression
5 Administer belladonna alkaloids simultaneously with morphine in a ratio of one part to twenty five of morphine	Clinical experience has demonstrated this to be the optimal ratio for man for surgical anesthesia
6 Consider body weight as well as age in judging dosage for infants and children	Disproportion between age and body weight is frequently observed in children

REFERENCES

Cullen, S C, and Alexander, F A D Preanesthetic Medication, Am J Surg, 24 428–434, 1936

Name John Smith Ⓜ F Age 47 Wt 200 Nationality U.S.
Address 202 Spring Street
TPR 98,80,20 Hb 85% RBC 5.5 WBC 10,000 BMR +10 BP 160/90 Special Lab
Urinalysis negative

PREOPERATIVE **RESPIRATORY** **POSTOPERATIVE**

Tb ____ None ____ None ____ Con

Cough ____ Asthma ____ Emphysema ____ Bronchitis, etc. ____

Airway ____ Oral sepsis ____ Collapse ____

Misc. ____ Pneumonia (L B H) ____

Misc. ____

CIRCULATORY

CV dis. ____ None ____ None ____ Hemorrhage ____

Tachy ____ Brady ____ Ven. insuff. ____ Tachycard ____ Bradycard ____

Hypertn ____ Hypoten ____ FC I IIa-IIb-III ____ Circ. Depression ____ Shock ____

Misc. ____ Misc. ____

GENITO URINARY

Uremia ____ Incontin ____ Ret ____ None ____ None ____ Cystitis ____

Imp. func ____ Cyst ____ Catheterized 3 days ____

Misc. ____ Misc. ____

GASTRO INTESTINAL

Obstruct ____ Distention ____ None ____ None ____ Ileus ____ Peritonitis ____ Dist ____

Nau. Em. Op Day ____ Recent ____ Nau. Em. 1st and 2nd day (Began Duration Severity)

Misc. upper right quadrant pain Misc. ____

CENTRAL NERVOUS SYSTEM

Lues ____ Irrat ____ Lesion ____ None ____ None ____ Emot. Dist. ____

Headache ____ Headache ____ Paralysis ____

Misc. ____ Misc. ____

MISCELLANEOUS

Addison ____ Alkal ____ Diabetic ____ Consciousness returned in room 1 hr post anes.

Leuk ____ Epilep ____ Anem ____

Drug addict ____

Hypomet ____ Spec. tox ____

Mal'g ____ Obese ____ Senil ____

Other ____ Special medication none

Final Comments

(Signed) J. H. S. Anesthetist

Fig 2 The reverse side of the form shown in Fig 1 Preoperative and postoperative findings are essential for complete records Data from this record may be transferred to punch cards for statistical studies

13 *Position of patient* Indicate the time and nature of changes in posture, i e, prone, supine, lateral, Trendelenburg, lithotomy, sitting, etc (Table V, p 84)

CLASSIFYING THE PATIENT AS AN OPERATIVE RISK

Risks are classified as A, B, C, or D, or as 1, 2, 3, or 4 according to the following criteria Note the class on the anesthesia record

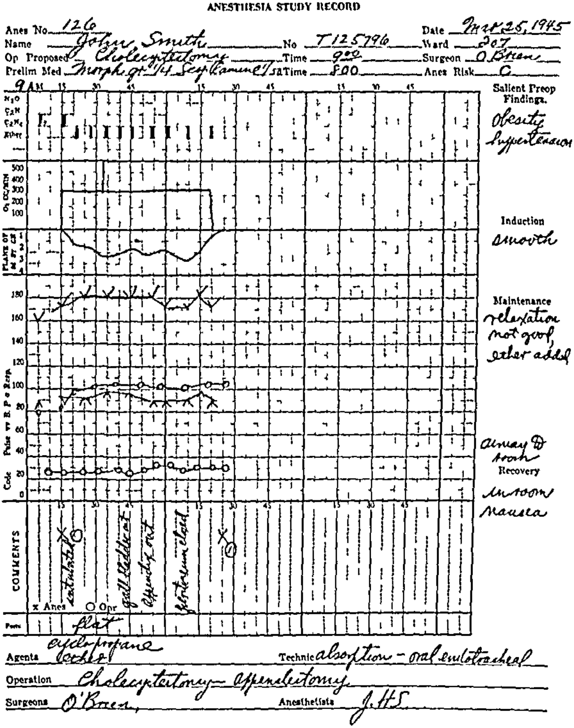

FIG 1 A suitable chart for anesthesia records

tory obstruction, laryngeal spasm, or cyanosis Record significant manipulations or points of interest in progress of operation

c *During immediate recovery period* Note the occurrence of retching, vomiting, respiratory depression, spasm, excitement, delirium, circulatory collapse, etc

12 *Medication* Fluids and other treatment administered during operation Note time of administration, route, quantity, and therapeutic effect (if any)

Name John Smith — Ⓜ F — Age 47 — Wt 200 — Nat U.S.
Address 202 Spring Street
TPR 98.8/20 ... 85 ... RBC 5.5 — WBC 10,000 — BMR +10 — BP 160/90 — Spec. Lab.
Urinalysis negative

PREOPERATIVE — POSTOPERATIVE

RESPIRATORY

Tb — None — None — Cough
Cough — Asthma — Emphysem — B on hitis, etc.
Airway — Oral sepsis — Coll pse
Misc. — Pneumonia (L B II)
Misc.

CIRCULATORY

C.V. dis. — None — None — Hemorrhage
Tachy — Brady — Ven. In t b — Tachyca d — Bradycard
Hypertn — Hypoten — PCI IIa-IIb-III — Circ. Dep ession — Shock
Misc. — Misc.

GENITO URINARY

Ur ma — I contin — Retent — None — None — Cystitis
Imp. func. — Cyst — Catheterized 3 days
Misc. — Misc.

GASTRO INTESTINAL

Obstruct — Distention — None — None — Ileus — Periton tis — Dist
Nau. Em. Opr. Day — Recent — Nau. Em. 1st and 2nd day (Began — Duration — Severity)
Misc. Upper right quadrant pains — Misc.

CENTRAL NERVOUS SYSTEM

Lues — Irrit — Lesion — None — None — Emot. Dist.
Headache — Headache — Paralysis
Misc. — Misc.

MISCELLANEOUS

Acidos — Alkal — Diabetic — Consciousness returned in room 1 hr post anes.
Leuk — Epilep — Anemia
Drug addict
Hypomet — Spec. tox.
Malig — Obese — Senil
Other — Special medicat none

Final Comments

(signed) J. H. S.
Anesthetist

Fig 2 The reverse side of the form shown in Fig 1 Preoperative and postoperative findings are essential for complete records Data from this record may be transferred to punch cards for statistical studies

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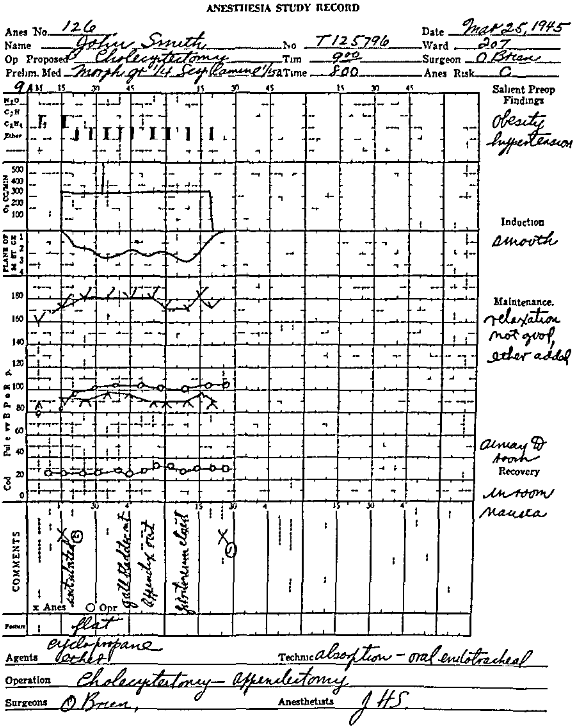

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Name *John Smith* (M) F Age *47* Wt *200* Nationality *U.S.*
Address *202 Spring Street*
TPR *98,80,?* *85%* RBC *5.5* WBC *10,000* BMR *+10* BP *160/90* Special Lab
Urinalysis *negative*

PREOPERATIVE POSTOPERATIVE

RESPIRATORY

Tb None None Cough
Cough Asthma Emphysem B on hi is, etc.
Airway Oral sepsis Coll pse
Misc. Pneumonia (L R ll)
Misc.

CIRCULATORY

CV dis. None None Hemorrhage
Tachy Brady Vas instab. Tachycard Bradycard
Hyperten Hypoten F C I IIa-IIb-III Circ. Depression Shock
Misc. Misc.

GENITO URINARY

Uremia Incontin R t nt None None Cystitis
Imp. func. Cyst Catheterl d *3* d ys
Misc. Misc.

GASTRO INTESTINAL

Obstruct Distention None None Ileus Peritonitis Dist
Nau.-Em. Opr Day Recent Nau. Em. *1st and 2nd day* (Began Duration Severity)
Misc. *Upper right quadrant pains* Misc.

CENTRAL NERVOUS SYSTEM

Lues Irrit Lesion None None Emot. Dist.
Headache Headache Paralysis
Misc. Misc.

MISCELLANEOUS

Acidos Alkal Diabetic Consciousness eturned *in room ½ hr post anes*
Leuk Epilep Anem-s-p
Drug addict
Hypomet Spec. tox
Mal'g Obese Sen'l
Other Special m dication *none*

Final Comments

(Signed) *J. H. S.* Anesthetist

Fig 2 The reverse side of the form shown in Fig 1 Preoperative and postoperative findings are essential for complete records Data from this record may be transferred to punch cards for statistical studies

13 *Position of patient* Indicate the time and nature of changes in posture, i e, prone, supine, lateral, Trendelenburg, lithotomy, sitting, etc (Table V, p 84)

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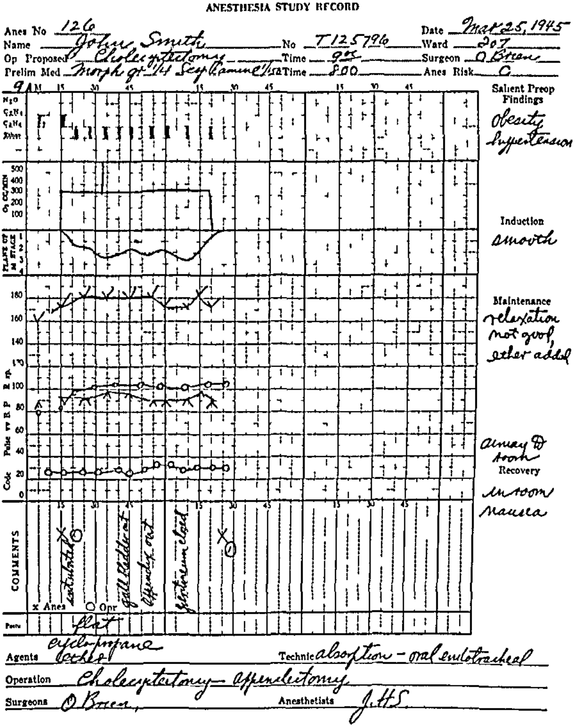

FIG 1 A suitable chart for anesthesia records

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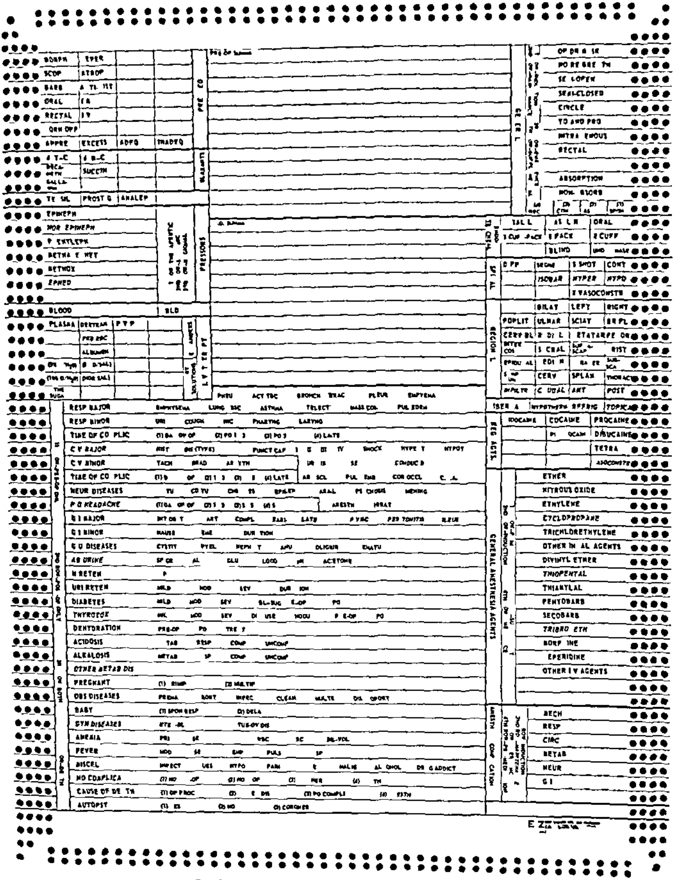
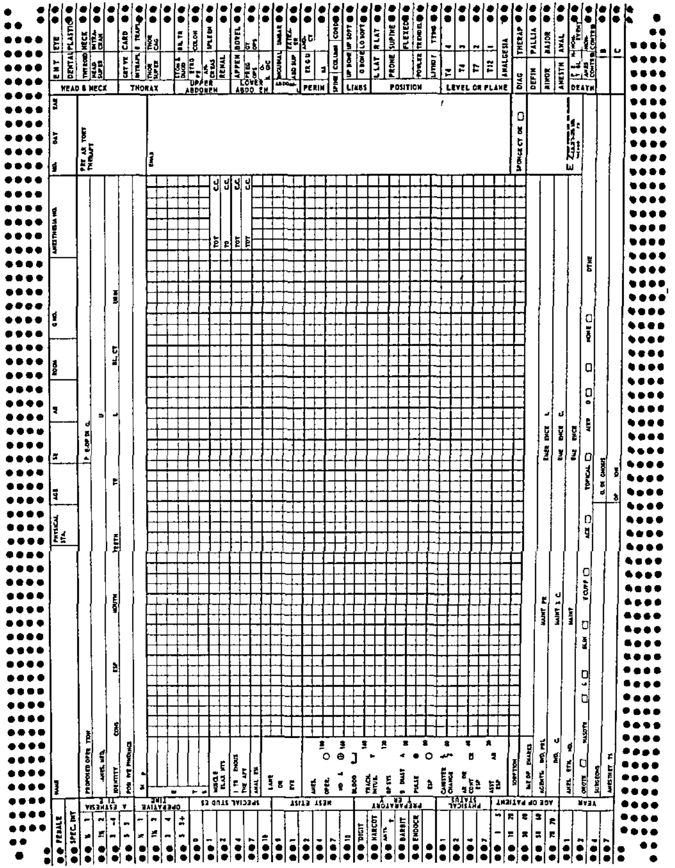
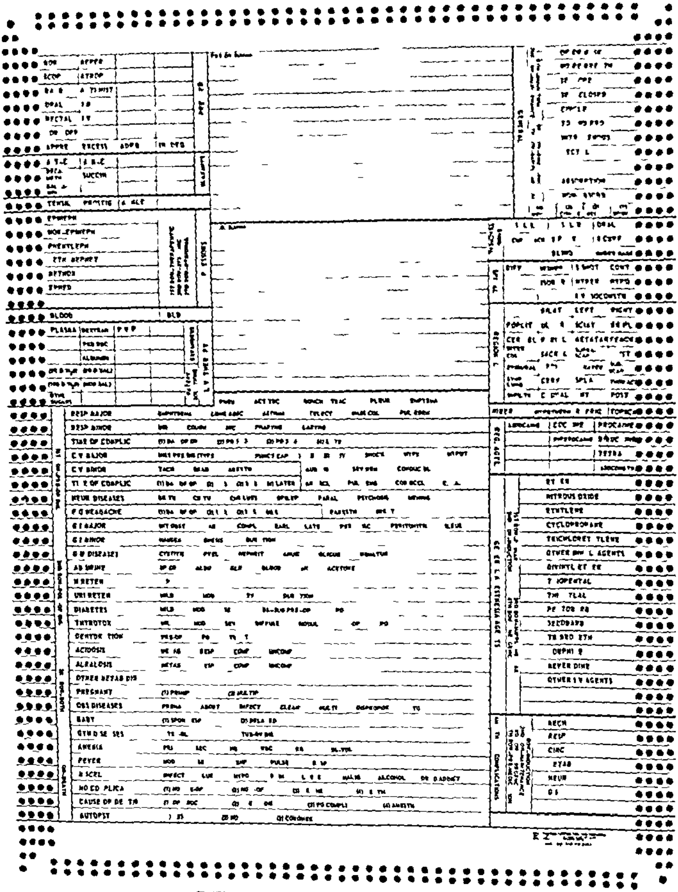
c *During immediate recovery period* Note the occurrence of retching, vomiting, respiratory depression, spasm, excitement, delirium circulatory collapse, etc

12 *Medication* Fluids and other treatment administered during operation Note time of administration, route, quantity, and therapeutic effect (if any)



B The reverse side used for postoperative follow up


HEAD & NECK
THORAX
UPPER ABDOMEN
LOWER ABDOMEN
PERIN
LIMBS
POSITION
LEVEL OR PLANE
DIAG
DEFIN
MINOR
ANESTH
DEATH
THERAP
PALLIA
MAJOR
ANAL
ENT
EYE
DENTAL
PLASTIC
THYROID
NECK
CARD
RENAL
APPEN
BOWEL
SPINE
COLUMN
CORD
R LAT
L LAT
PRONE
SUPINE
FLEXED
TRENDEL
LITHOT
T4
T7
T12
ANALGESIA
FEMALE
SPEC. INT
ANESTHESIA TIME
OPERATIVE TIME
SPECIAL STUDIES
REST EST
PREPARATORY
PHYSICAL STATUS
AGE OF PATIENT
YEAR
DIGIT
NARCOT
BARBIT
ENDOCR
NAME
PHYSICAL STA.
AGE
SEX
ANESTHESIA NO.
PROPOSED OPERATION
POST OPERATIVE
TEETH
MOUTH
SURGEONS
ANESTHETIST
BLOOD
PULSE



B The reverse side used for postoperative follow up

1 or A Risk A patient having no systemic defects who is undergoing a "minor" or "major" surgical procedure *Example* Young healthy adult undergoing hemorrhoidectomy or appendectomy

2 or B Risk A patient having a minor or not significant systemic defect who is undergoing a "major" surgical procedure *Example* An adult undergoing appendectomy who has uncomplicated essential hypertension

3 or C Risk A patient who is undergoing a "major" surgical procedure but who has in addition to the surgical condition another disease which would not in itself prove immediately fatal *Example* Appendectomy in a subject who has a hypertension with moderate cardiac hypertrophy

4 or D Risk A patient who is undergoing a "major" surgical procedure but who has in addition to his surgical condition a disease which itself might be immediately fatal *Example* Cardiac decompensation in a patient undergoing cholecystectomy for acute cholecystitis

Comment The demarcation between "minor" and "major" surgical procedures is difficult to define Therefore the distinction is purely arbitrary The classification of risk is a matter of opinion and can only be an approximation of an arbitrary nature

The American Society of Anesthesiologists has adopted the following classification

1 A patient having no systemic disease who is undergoing a surgical procedure Example A young, healthy adult undergoing hemorrhoidectomy or appendectomy
2 A patient having a minor and not significant systemic defect who is undergoing a surgical procedure Example An adult undergoing appendectomy who has uncomplicated essential hypertension
3 A patient undergoing a surgical procedure who has in addition to the surgical condition a systemic disease which is serious but is not one which might be immediately fatal Appendectomy in a subject who has hypertension and coronary sclerosis with definite evidence to myocardial disease
4 A patient who is undergoing a major surgical procedure who has in addition to his surgical disease, a disease which in itself might be immediately fatal Example Cardiac decompensation in the patient undergoing cholecystectomy for acute cholecystitis
5 An emergency operation being performed in a patient who has been graded as a 1 or 2 risk
6 An emergency operation in a patient who has been graded as a 3 or 4 risk
7 A patient who is moribund who needs urgent surgery

Coding (Punch Card) Systems

1 *Manual Classifying and Sorting* (Keysort Punch Card—McBee Company)

Features The anesthetic record is printed on a card bearing a double line of

holes on its borders A hand punch is used to extend the hole corresponding to the factor which is to be recorded to the edge to form a V shaped slot Each hole corresponds to an agent technique or complication Data is recorded directly or indirectly

(a) Direct recording—The various factors and details of anesthesia are assigned a particular hole on the perimeter When a factor is present the hole is punched out into a V shaped slot The cards are sorted by placing a spindle through the hole corresponding to the factor being studied The positive cards drop out of the stack since the hole has been punched out and are thereby separated from those in which the factor is negative

(b) Indirect recording—Numbers are assigned to various factors and to the holes in the card This system permits the recording of many more factors than the direct coding method The cards are punched and sorted in the same manner as in direct coding

2 *Mechanical Punching and Sorting* (Hollerith)

The various factors to be recorded are assigned a number in a code book (prepared by the American Society of Anesthesiologists) Data are transferred from the anesthetic record in code to a card $3\frac{1}{4} \times 7\frac{3}{8}$ and holes punched by a machine corresponding to the numbers written on the card This system permits mechanical sorting and recording of many more factors than the manual system The anesthetic record is separate from the statistical record

Uses To record data for statistical analysis

Comment The data is as reliable as the least conscientious member of the staff and is as correct as the opinion of the least experienced member of the staff

PULSE RATE

The quality of the pulse when correlated with blood pressure offers the best index of the status of the circulation during surgery Sites for palpation of the pulse during anesthesia are as follows (Fig 3)

1 External temporal artery anterior to meatus of the ear (most accessible, desirable, and commonly employed site)
2 Carotid artery at level of thyroid cartilage Palpation not always satisfactory in anesthetized subjects
3 External maxillary artery as it crosses mandible Simultaneous palpation of pulse and traction on jaw may be achieved while holding mask, if this vessel is prominent
4 Frontal branch of external temporal artery
5 Radial artery if either arm is accessible (on an arm board)

Comment

1 Always use a watch to count the pulse rate
2 Palpate pulse frequently and if necessary continuously (especially when administering cyclopropane, chloroform, ethyl chloride, or during shock, or other circulatory disturbances)
3 Record pulse rate on graph every five minutes in uncomplicated anes-

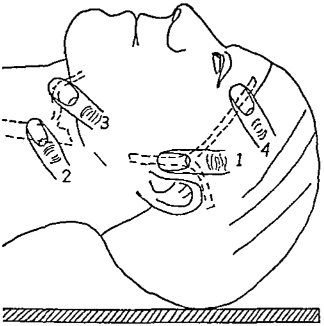


Fig 3 Sites about the head suitable for palpation of the pulse listed in the order of their importance
(1) External temporal artery
(2) Carotid artery
(3) External maxillary artery
(4) Frontal branch of external temporal artery

thesia *Note* quality and volume of the pulse as well as the rate and rhythm

4 Pulse rate unless correlated with blood pressure is not always a satis factory guide to state of circulatory system

BLOOD PRESSURE DURING ANESTHESIA

The arterial tension should be determined at regular intervals on all pa tients undergoing surgery regardless of the type of anesthesia employed or nature of the operation performed Repeated measurements correlated with the rate and quality of the pulse are *the best criteria of the status of the circula latory system*

Reasons for determining blood pressure

1 Forewarns of circulatory failure—shock, hemorrhage, deep anes thesia, vasomotor instability, or reflex circulatory changes

2 Warns of excess carbon dioxide in the inhaler
3 Indicates the presence of anoxia or asphyxia
4 Serves as a guide to the effect of therapy or medication administered during surgery

Materials required for determining blood pressure

1 Mercury sphygmomanometer mounted on a stand with a broad base or fastened directly to the anesthesia machine
2 Stethoscope of diaphragm type provided with a long extension tube
3 Towel and safety pin (for obese subjects)
4 Arm board (for obese subjects)

Procedure	*Reasons*
1 Abduct and extend the patient's right arm so that the palm rests in either of the anesthetist's axillae (Fig 4)	The anesthetist may thus hold the patient's arm to his side Both his hands remain free for application of cuff and stethoscope
2 Palpate brachial artery in the cubital fossa with forefinger	The artery is on side closest to body (medial)
3 Arrange the bell of the stethoscope over the artery so that the tube leads towards the head of patient Secure tightly with the tape provided for the purpose	Sounds are often indistinct if bell is not placed and securely fastened *directly over the artery*
4 Wind cuff securely about the arm above the cubital fossa Arrange tubings so that they point towards the head of the table	Tubing becomes kinked if it is not properly arranged
5 Test apparatus once or twice before anesthesia is started to ascertain if it is applied correctly and functioning properly	Readjustment is simpler before patient is draped and surgery started

Frequency of Readings

1 A pre anesthetic reading should be recorded and compared with the blood pressure recorded during the physical examination
2 A reading should be recorded as soon as the patient passes into third stage (*Do not inflate cuff during second stage Stimulation may cause excitement*)
3 A reading should be recorded at ten minute intervals if all is well, at five minute intervals during cyclopropane, spinal, nitrous oxide, avertin, or pentothal narcosis
4 A reading should be noted at five minute intervals or oftener if there has been any notable fall or pronounced elevation of blood pressure or if pre operative blood pressure was not with normal limits

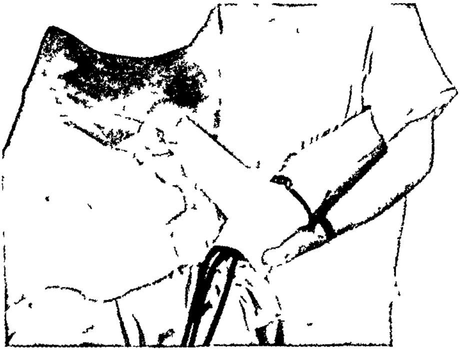


Fig 4a Applying cuff of sphygmomanometer The patient's palm is held in the anesthetist s axilla to allow use of both hands for winding the cuff

5 A reading should be noted at two or three minute intervals during the first fifteen minutes of spinal anesthesia

Care of Apparatus

1 Fold stethoscope neatly and place in cabinet of anesthesia machine or other designated place
2 Fold rubber tubing neatly and wrap cuff and arm band around it to form a neat compact bundle
3 Remove covering from the cuff and sterilize by boiling if soiled by secretions or blood

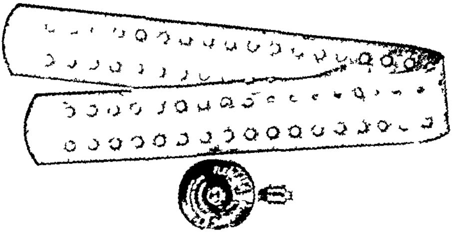


Fig 4b Stethoscope bell with nipple on back and perforated rubber strap for securing to the arm

Comment	Reasons
1 Apply cuff to left arm before patient is turned when the prone position is contemplated	The attachments to the manometer will lead to the right side of the table during the operation
2 Arrange cuff on uppermost arm when the patient is to lie on his side	Compression of artery of undermost arm frequently occurs Sounds are inaudible or indistinct
3 Extend and abduct the arm of obese subjects on a board and fasten loosely	Auscultation is more satisfactory if arm is abducted
4 Deflate the cuff completely between readings	*Ischemia of the extremity may be disastrous*
5 Do not apply the cuff to the arm being used for intravenous therapy	Stasis, even though intermittent, causes a clot to form which results in plugging of the needle
6 When a pulse of good volume is palpated but sounds are inaudible, check apparatus before notifying the surgeon that a hypotension exists	The bell of the stethoscope may have shifted so that it is no longer over the artery
7 *Do not hang stethoscope about the neck between readings* Tuck it beneath the pad of the operating table when not in use	The instrument usually becomes tangled at the most inopportune moments and restricts the anesthetist's movements
8 Place manometers mounted on stands well behind the head of the table	The stand interferes with the movements of surgical team when placed along side the table
9 Do not allow the bulb which inflates the cuff to fall to the floor	The valve and air release screw are sensitive structures and easily damaged
10 For pediatric patients less than one year old use 1″ arm band	The larger cuff is ineffective
11 For pediatric cases place the bell of stethoscope in popliteal space and cuff above knee	The tibial arterial is larger and sounds are louder

PART II

INHALATION ANESTHESIA

A TYPE AND METHODS

Available Drugs

Gases Nitrous oxide, ethylene, cyclopropane

Volatile liquids Ether, vinethene, chloroform, ethyl chloride and trichlorethylene

Methods of Administration Inhalation anesthesia is administered by the open or closed methods as follows

1 Open
   a Insufflation The drug in gas or vapor form is mixed with air or oxygen and is conducted into the nostrils, mouth, nasopharynx, or trachea
   b Open Drop The drug in liquid form is vaporized on a gauze or other type of mask, mixed with air or oxygen and inhaled
2 Semi open
   a Insufflation Same as open insufflation, except that a towel or other protecting device is wrapped about mouth and nose to prevent escape of gases or vapors
   b Drop Same as open drop method, except that a towel or other enclosing device is wrapped about mask to minimize the escape of gases or vapors
3. Semi closed Mixtures of gases or vapors are enclosed in an inhaler equipped with an expiratory valve to allow the escape of excess gases and carbon dioxide
4 Closed Mixtures of gases or vapors are enclosed in an inhaler and completely rebreathed The patient's metabolic requirement of oxygen is added from an external supply and carbon dioxide is removed by chemical absorption

Apparatus and Equipment for Inhalation Anesthesia

Inhalation anesthesia is administered by means of open masks, insufflators, or inhalers Inhalers are usually parts of *machines* All appliances for administering inhalation anesthesia (from the simplest mask to the most complex inhaler) have these essential features

1 A source of oxygen
2 A device or means for the disposal of carbon dioxide
3 A device to vaporize liquid anesthetic drugs

Open Masks

Definition Open masks are devices, usually fashioned from wire or screen, to fit over the face and nose of the patient Layers of gauze, flannel or similar substances, upon which the drug may be vaporized, are draped and fastened over the metal framework Many types have been devised

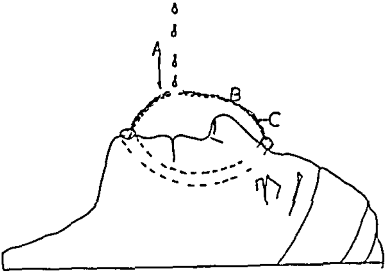


FIG 5 The open drop technique simple as it is embodies the three cardinal features of all inhalation anesthesia appliances (A) a source of oxygen which in this case is air (B) a means for the unimpeded disposal of carbon dioxide which is the meshes of the gauze screen, and (C) a device for vaporizing the liquid agent which in this case is the gauze covering

but all serve the same purpose (Fig 5) The air supplies the oxygen, and carbon dioxide escapes through the mesh of the cloth

Insufflators

Definition An insufflator is a device so arranged that air, oxygen, or other gases may be bubbled through certain volatile liquids The resultant vapor becomes mixed with the gas and is conducted to the upper portion of the respiratory tract through a catheter or other conduit and inhaled (Fig 6)

Anesthesia Machines

Definition An anesthesia machine is a complex apparatus for the administration of anesthetic gases and vapors by inhalation

Constant features which appear on anesthesia machines

1 An inhaler composed of a mask and rebreathing bag and necessary connecting pieces
2 A flowmeter for measuring gases and connecting tubes for leading gases to the inhaler (see flowmeters)
3 A vaporizer for volatile liquid anesthetic drugs (see vaporizers page 35)

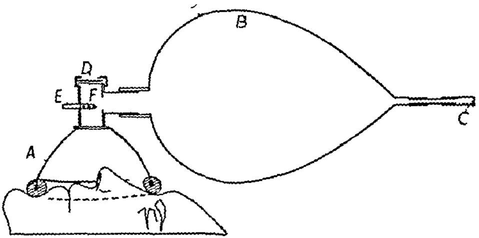


FIG 6 Cross section of a semiclosed inhaler composed of (A) a closed mask and (B) a breathing bag A continuous flow of gases is admitted from a flowmeter through the (C) inlet tube Exhalations excess gases and vapors escape through (D) the adjustable valve A variable amount of rebreathing occurs, depending upon the flow of gas size of the mask and the bag tidal volume of the patient and patency of the valve The bag may be closed from the mask by (E) the obturator which allows the patient to breathe room air through (F) the vents

4 An expiratory valve or other outlet for the elimination of exhaled gases, particularly carbon dioxide (Fig 6)
5 A yoke and reducing valve for attachment of one or more cylinders of oxygen (Fig 11)

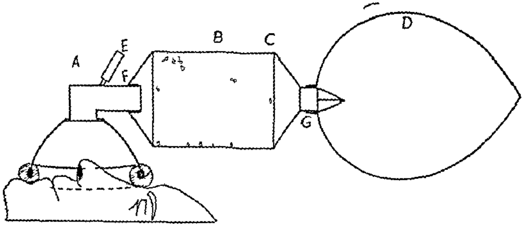


FIG 7 Simplified form of to and fro inhaler composed of (A) a mask (B) a canister charged with (C) soda lime and (D) a five liter rebreathing bag Gases and vapors are admitted into the inhaler through the (E) inlet During expiration gases pass over the soda lime to the breathing bag during inspiration the direction is reversed The contents of the inhaler are exposed to the absorbent twice The slip joints (F) and (G) allow the inhaler to be dismantled or the canister to be removed

6 A yoke and reducing valve for attachment of one or more cylinders of nitrous oxide (or ethylene)
7 A yoke and reducing valve for attachment of one cylinder of carbon dioxide
8 A yoke and reducing valve for a cylinder of cyclopropane

Features not constantly present, but desirable

1 A filter for the chemical absorption of carbon dioxide (Fig 7)
2 A valve for quickly flooding the inhaler with oxygen in event of emergency
3 A sphygmomanometer attached to the apparatus at a convenient point
4 An automatic mixing flowmeter capable of delivering gases in certain fixed percentages (the McKesson machine is equipped with a meter)
5 A pressure gauge attached to each yoke to record pressures of compressed gases in supply cylinders
6 A cabinet, drawers, writing table, etc
7 A water, mercury, or diaphragm type of manometer for measuring and controlling the pressure in the inhaler

Inhalers

Description Inhalers are devices from which a subject breathes gases or vapors Two types are employed for anesthesia (a) the semi closed, and (b) the closed

a *The semi closed inhaler* is composed of a mask, a breathing bag, an exhalation valve, and necessary slip joints and sleeves A continuous flow of gases and vapors must be delivered into the bag which acts as a reservoir The excess and the exhaled gases escape through the exhalation valve (Fig 6)

b *The closed inhaler* is composed of a snugly fitting mask, an absorption system for carbon dioxide, a rebreathing bag, and necessary slip joints and sleeves The exhaled gases are rebreathed after carbon dioxide is removed (Fig 7) A flow of oxygen for the metabolic requirements of the patient is provided from a storage cylinder

Face Pieces

Description A face piece, often referred to as a mask, is composed of a metal, celluloid, or hard rubber body (Fig 8) and a soft rubber, usually inflatable, face cushion (Fig 9) The body communicates with the rebreathing bag by means of a slip joint

Uses The face piece acts as a closed mask for semi closed and closed inhalers

Features

1 Face pieces should be as small as possible to minimize "dead space"
2 Face pieces should have wide apertures leading to the other portions of the inhaler (at least 2 5 cms)
3 Face pieces should be shaped so that they may be held comfortably in one hand by the anesthetist

4 The cushion should be soft and fit snugly and comfortably over the face

5 The cushion should be well inflated and leakproof if of the inflatable type

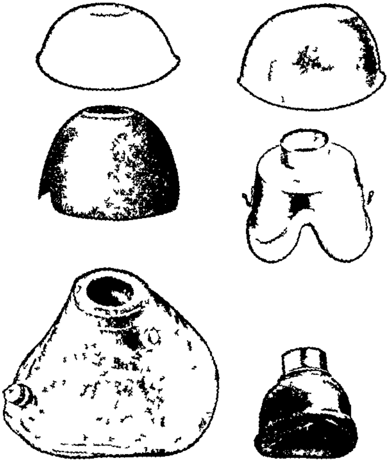


FIG 8 Face pieces used to form the mask for inhalation anesthesia Some are made of plastic substances others of rubber still others of metal (Courtesy of Richard Foregger Ph D)

Care of Face Pieces

1 Immediately after use, disconnect the face piece from remainder of inhaler Scrub with soap and water, rinse with 70% alcohol, wipe dry, and wrap in a clean dry towel

Comment

1 Always select a face piece which fits the patient's face snugly to assure an airtight fit

2 Never use creosol or other disinfectants of the phenol type to disinfect rubber *Rubber becomes impregnated with the phenol and may cause burns*

Head Bands

Definition Head bands are straps composed of sheet rubber, plastic, or other

elastic substances They are shaped to fit about the occiput, and pass along side the face to the face piece (Fig 10)

Synonym Mask retainer, mask harness

Uses They hold the face piece securely and comfortably to the face

Features

1 Head bands should possess sufficient resilience to allow as loose or snug an application of the face piece as desired

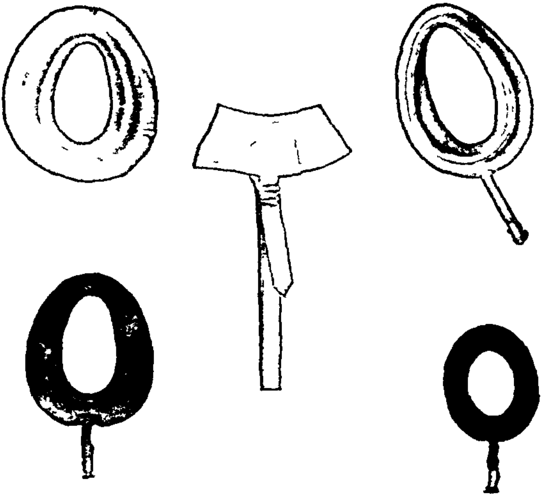


Fig 9 Face cushions used to complete the mask for inhalation anesthesia. These cushions slip over the edges of the face pieces shown in Fig 8 (Courtesy of Richard Foregger Ph.D)

2 They should be composed entirely of rubber or covered with a substance which is easily cleaned in event of soiling

3 They should be free from sharp hooks or prongs or other metal pieces which may injure the patient or anesthetist

Breathing Bags

Description Breathing bags for inhalation anesthesia are usually composed of rubber They are placed at some convenient point in the inhaler and act as reservoirs for mixtures of vapors and gases

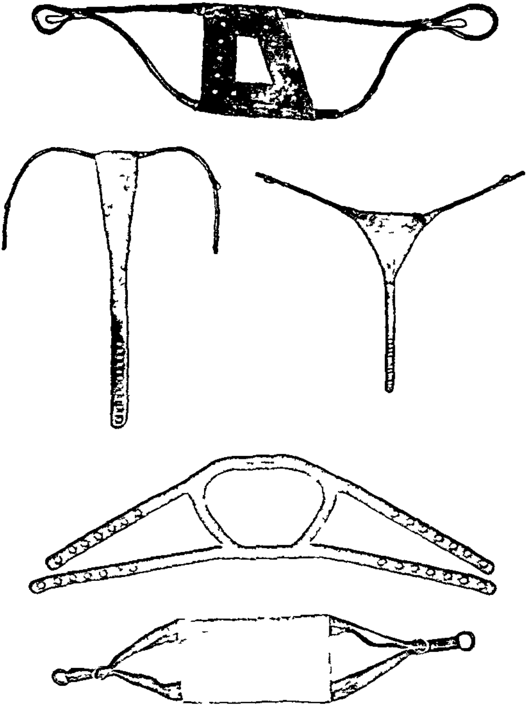


FIG 10 Various types of head bands used to secure masks to the patient's face (Courtesy of Richard Foregger Ph D)

Features

1 They are usually ovoid in shape and vary between one and five liter capacity, depending upon the type of inhaler for which they are de signed

2 They are composed of light gum or other type of rubber which will not offer resistance to respiration

3 Each has a wide outlet to the inhaler at one end (2 5 cms or more in diameter) An inlet nipple may be present at the other end in designs for the semi closed inhaler

Care of Bags

1 Cleanse interior and exterior with soap and water Rinse and allow to drain by inverting the wide outlet downward
2 Always store rubber pieces in a cool place when not in use
3 Do not cleanse with creosol or other disinfectants of the phenol type
4 Do not allow bag to remain distended with gases, when not in use

Comment

1 Anesthetic gases diffuse through rubber and hasten its deterioration
2 Perforations or tears should be patched immediately with rubber cement and strips of gum rubber *Do not use adhesive plaster*

Cylinders for Storage of Gases

Anesthetic and other gases employed for anesthesia are compressed into steel cylinders for storage and transportation

Features of Cylinders

1 The walls, constructed of 3/8″ steel, are capable of withstanding pressures which vary between 3000 to 4000 pounds per square inch They must resist 5/3 of the currently used or *service* pressure

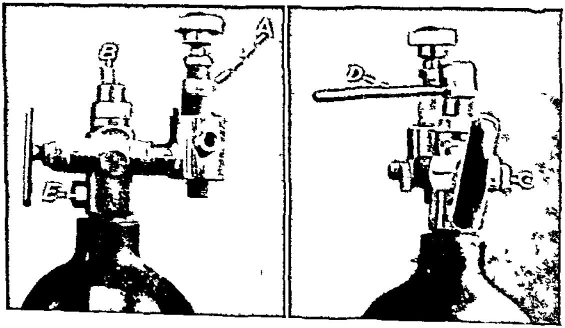


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FIG 11(a) and (b) (A) Reducing valve and yoke (B) Cylinder valve (E) Bolt containing core of soft metal which melts and acts as a safety plug in the event of exposure to high temperatures. (C) Screws for securing cylinder to the yoke (D) Handle for cylinder valve

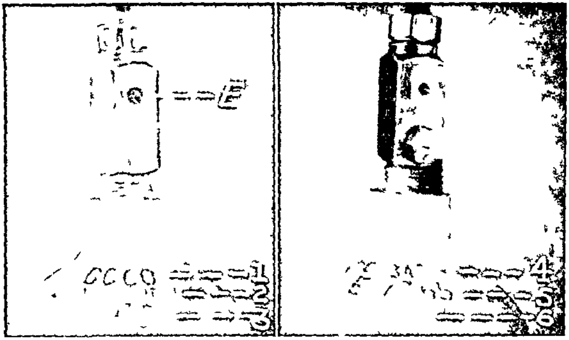

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Fig 12(a) and (b) Markings on the shoulder of storage cylinders for compressed gases
(1) Name or initials of manufacturer
(2) Location of the manufacturer
(3) Symbol of the laboratory which tested the cylinder after five years use and date of test (P) Port for exit of gases.
(4) Interstate Commerce Commission cylinder type (3A) used for anesthetic gases Service pressure 2025 lbs. per square inch.
(5) Size of cylinder and manufacturer's number
(6) Symbol of original testing laboratory

2 All possess a valve which is a permanent part of the cylinder This controls the flow from the cylinder to the reducing valve on the machine (Fig 11)

3 All are provided with a safety plug containing a metal which melts and releases the contained gases in the event the cylinder is exposed to excessively high temperatures (Fig 11)

4 All have the following identifying marks engraved upon the shoulder Type, serial number, date cylinder was commissioned, date tested, insignia of testing laboratory, service pressure, and name and address of the manufacturer of gases owning it (Fig 12)

5 Refilled cylinders are sealed at the valve port, tagged with weight of gas, equipped with a new washer, and labeled

Care of Cylinders	*Reason*
1 Always close valves after using a machine or before removing cylinder from a yoke	The cylinder may not be empty and gases will escape if they are jarred loose in the yoke or if one attempts its removal

2 Replace worn washer with the new one provided with each newly filled cylinder	Gases leak if a durable washer is not interposed between port of the valve and nipple of the yoke
3 Store all cylinders in a cool place away from combustible materials	Gases expand when warmed, and the pressure in the cylinder becomes excessive
4 Label exhausted cylinder "empty" with chalk or other erasable marking substance	Storing empty with full cylinders may cause confusion and lead to accidents
5 Close valves on all empty cylinders	Dirt, moisture, and other deleterious agents must be excluded from the interior of the cylinder
6 Fasten cylinders in an upright position or place in a rack designed for the purpose	The valve is the most vulnerable part of the cylinder It easily breaks off if the cylinder is upset

Identification *Cylinders are identified by the color of their exteriors as well as by their labels* The following colors have been adopted by the U S Bureau of Standards

	Color	*State of Drug in Cylinder*
Cyclopropane (C_3H_6)	orange	liquid
Ethylene (C_2H_4)	red	gas
Nitrous oxide (N_2O)	blue	liquid
Helium (He)	brown	gas
Oxygen (O_2)	green	gas
Carbon dioxide (CO_2)	grey	liquid
Carbon dioxide oxygen	grey green	gas
Helium oxygen	brown green	gas

Reducing Valves

Definition A reducing valve is a valve usually of the diaphragm type interposed between main cylinder valve and pin valve on flowmeter

Purpose It reduces the high pressure in the cylinder to slightly above atmospheric pressure so that a constant flow of gases in small volumes can be obtained

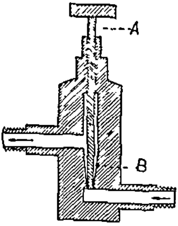


FIG 13 Cross section of a reducing valve of the pin type (A) The pin fits into (B) the seat If the pin is screwed too tightly the seat is damaged and the fine adjustment is lost

Types

a Diaphragm type Usually controlled by an adjustable screw type arrangement The flow of gases is initiated by turning the screw inward (clockwise)

b Pin valve type Composed of a fine pin with a tapered end which may be screwed into a ground metal seat (Fig 13) Flow varies as tapered needle is screwed in or out of the seat

Care of Reducing Valves

1 Turn reducing valves until flow of gas ceases
2 Never tighten (screw in) valves of the pin type The seat or the pin (whichever is softer) becomes worn and the valve develops a leak or loses its fine adjustment
3 Do not oil or grease any reducing valve on any high pressure gas system
4 Always close reducing valves before turning on the cylinder valve The high pressure from the cylinder may suddenly be transmitted to the flowmeter or inhalers
5 Always turn off reducing valves (after turning off the main valves) when the anesthesia apparatus is not in use
6 Wipe pin valves and seats with ether or acetone to remove dirt Dry with clean gauze

Pin Valves

A device which permits variation in size of an orifice for altering flow of gases discharged from a point of higher pressure to a lower one Usually consists of a pin which screws into a tapered slot

Comment

In the Foregger apparatus the pin valve serves dual purpose of regulating gas flow and reducing pressure It is the only valve between main cylinder valve and flowmeter

Yokes

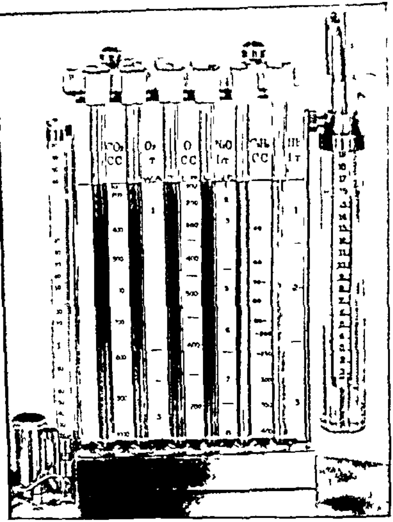
Definition Yokes are metal clamps with adjustable screws which secure the cylinders to the apparatus or reducing valves They are equipped with nipples which fit snugly into the inlet socket or port of the cylinder valve (Fig 11)

Pin Index System

The pin index system consists of a combination of two pins projecting from the yoke assembly and arranged to fit into matching holes on the cylinder valve Each gas has a certain combination of positioning of holes and pins so that no interchange is possible on yoke designed to accommodate a specific gas

Flowmeters

Definition A flowmeter is a device for measuring volumes of gases or vapors under pressure as they effuse from storage cylinders or other containers



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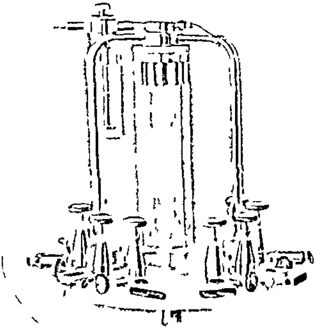
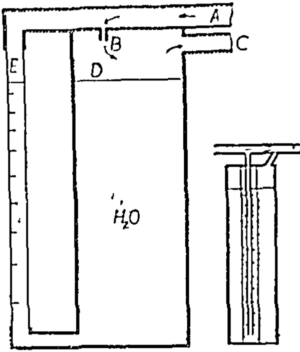


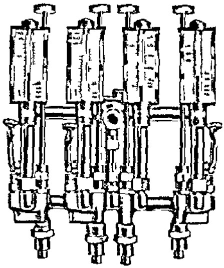


c

Fig. 14a, b, c. (a) A typical flowmeter head of the hydraulic ("Outside") type. (Courtesy of Richard Foregger, Ph.D.)

(b) A typical flowmeter head of the hydraulic ("Inside") type.

(c) Schematic diagram illustrating the operation of the hydraulic flowmeter. The gas passes from the cylinder and reducing valve into (A) the inlet tube, through (B) a narrowed orifice to (C) the delivery tube leading to the inhaler. The passage of gas through the narrow orifice causes the pressure in (A) to exceed that over the water in (D). This difference in pressure causes a depression of the column of water in (E). The greater the amount of gas flowing through orifice (B), the greater the pressure developed in (A), and the greater the depression of the meniscus in (E). (E) is calibrated in such a manner that the amount of depression indicates the flow in liters or fractions of a liter per minute. Calibrations apply to the gas indicated or to a gas of identical molecular weight. Inset shows principle of the inside type of flowmeter. The principle of operation is identical in both types. The tubes on the inside type are enclosed in the jar; on the outside type they are individually mounted on a scale placed in front of the water reservoir.



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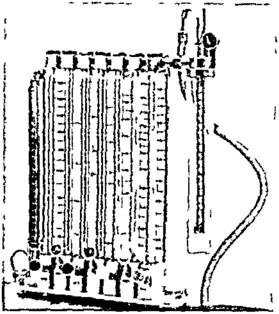

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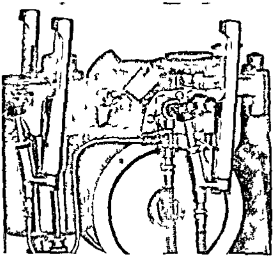


3

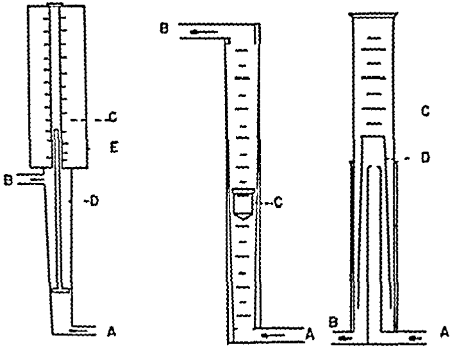
FIG 15a 1 Flowmeter used on Heidbrink 2 Rotameter (Foregger) 3 Flowmeter used on McKesson

Types Three types are commonly employed for anesthesia

1 *Hydraulic type* Also known as the "wet" flowmeter A constriction in the inlet tube causes an increase in pressure of the flowing gas This increase in pressure is transmitted to a column of water which is depressed in a calibrated tube in proportion to the flow of gas (Fig 14)

2 *Dry or floating gauge type* The flow of gases suspends a spherical or cylindrical float in a transparent tube, the sides of which are calibrated in liters or gallons per minute (Fig 15) The rotameter is of this type

3 *Gauge type* A constriction in the inlet tube increases the pressure of flowing gases The increased pressure is transmitted to a diaphragm which works a clocklike mechanism and records flow of gases in liters or gallons per minute (Fig 16)



1 2 3

FIG 15b Dry types of flowmeters constructed on the variable orifice principle (1) Type used on Heidbrink The gases enter at A into tapered tube As flow increases plunger is elevated higher into tube to permit gas to flow around edge and the stem D is pushed further into transparent tube C along scale E (2) Rotameter type of flow meter Plastic rotating bobbin C is suspended in transparent tapered tube by the stream of gases which enter at A and leave at B The bobbin is spherical in certain types of units (3) Type used on the McKesson apparatus operated on the same principle The gases pass through the nozzle type orifice B into tapered tube which is elevated into calibrated transparent tube C in proportion to flow of gases The gases enter the apparatus at A and leave at B

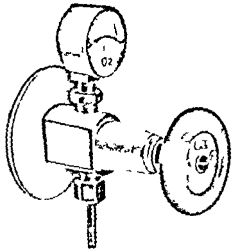


FIG 16a Diaphragm or gauge type of flowmeter

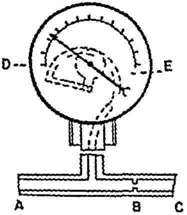


FIG 16b Cross section of gauge type of flowmeter The gases enter (A) the tube through (B) the orifice to (C) the delivery tube The narrow orifice causes a difference in pressure between (A) and (C) which is transmitted to (D) the diaphragm The diaphragm operates a clockwork mechanism (E) The dial is calibrated in liters or fractions of a liter per minute

Care of Flowmeters	*Reason*
1 Never lubricate valves or other parts of a flowmeter with grease or oil	Explosive mixtures may form
2 Always close the reducing valve before the cylinder valve is turned on	The high pressure from the cylinder is transmitted to the flowmeter
3 Always maintain the water in a hydraulic flowmeter at its prescribed level	Incorrect volumes of gases are metered if water level is low
4 Cleanse flowmeter jars with diluted hydrochloric acid *once a month* Rinse and refill with distilled water	Water becomes discolored and jar coated with film in due time

Comment

1 *Each flowmeter is calibrated only for that gas which it is to measure* Substitution of one gas for another may result in inaccurate measurement of volumes unless corrections are allowed

2 The flow is gauged at atmospheric pressure (76 cm Hg) and room temperature (25°C)

3 Each meter must have a reducing valve interposed between it and the cylinder valve to deliver the gases at a safe pressure and a constant rate

4 Gases may be measured in terms of the metric system in *liters* or fractions of liter per minute, or in terms of the English scale in *gallons* per hour *The former is preferred*

5 Hydraulic flowmeters for anesthetic gases as a rule, measure *small volumes of gases* more accurately than other types

6 Hydraulic flowmeters do not humidify the gases they measure unless the gases are bubbled through the water

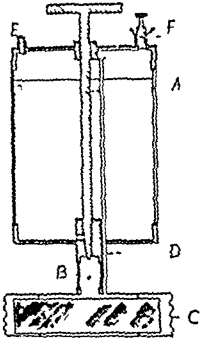
Vaporizers

Definition Vaporizers are devices used to volatilize low boiling liquid anesthetic drugs

They may be placed (1) at some point in the inhaler so that vapor

---

FIG 18 Schematic diagram of a typical bubble type vaporizer The (A) motor driven pump delivers a stream of compressed air whose volume may be controlled by (B) the valve through the (C) container for the volatile liquid The air is divided into fine bubbles which facilitates vaporization The air and the vapor are conducted through (D) the trap which prevents the accidental passage of liquid to the patient The (C) container is surrounded by the (E) water bath which is warmed in (F) the container by (G) electric heater



17a

17b

FIG 17a Ether vaporizer of dropper type (A) The pin valve adjustment controls the size rate and drop formation which may be observed through (B) the window The drug drops upon the (C) copper screen and is vaporized by the gases in the inhaler (D) The tube allows the pressure over the surface of the liquid to be equalized with that in the inhaler (E) The vent is opened when the cup is filled through (F) the funnel to allow displacement of air by the liquid

(b) Type used for to and fro filter (Courtesy Richard Foregger Ph D)

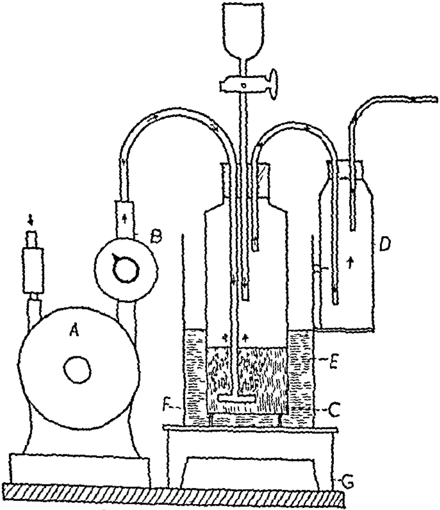


FIG 18 (See opposite page for description)

ization occurs in the inhaler or (2) they may be located outside the inhaler so that the vapors must be delivered to it

Types

1 *Dropper Type* (Fig 17)
   a The liquid contained in a cup passes through a needle valve and drops on a copper screen placed in the path of inhaled or exhaled gases The vapors are caught in the current
2 *Bubble Type* (Fig 18)
   a Gases, usually air, oxygen, or mixtures of nitrous oxide and oxygen, are bubbled through the liquid contained in a jar The vapor and gases are conducted to the inhaler (see insufflators page 23)
3 *Gauze or Wick Type* (Fig 19)
   a Exhaled or inhaled gases are conducted over a gauze or wick which is continually soaked by partial immersion in the liquid

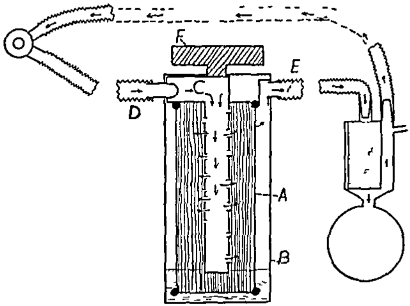


Fig 19 The wick type of vaporizer for volatile liquids This type of vaporizer is usually introduced into either the delivery or return tube of the circle filter The (A) wick dips into the (B) partially filled jar and is thus constantly soaked with the liquid The gases pass through from tube (D) over the wick and out through (E) together with the vapor (F) Control allows by pass of some of the gases to regulate the amount of drug added to the inhaler If the vaporizer is on the exhalation side of the inhaler, the vapor is diluted with the gases in the canister and the bag If on the inspiratory side the strong' vapor passes into the mask and mixes with the gases in the lungs first

4 *Heater Type*
   a The drug is enclosed in an air tight container equipped with a needle valve from which the pure vapor is delivered to the inhaler The drug is vaporized by warm water or a chemical heater (Oxford) which surrounds the container

Comment	*Reason*
1 Discard unused liquid at the end of each day	Most liquid drugs are decomposed after exposure to light, air, or heat

2 Close the vent (bubble type) except when filling the vaporizer	The vent is a source of a leak The back flow of gases prevents proper dropping of the liquid
3 Remove wicks from the jar and allow to dry when machine is not in use	Condensed water vapor from patient's exhalations often wets wick and reduces efficiency
4 Tighten ether jars securely in their sockets	The rim of the jar is frequently a source of leaks

The Chemical Absorption of Carbon Dioxide

Principle The carbon dioxide is absorbed by the passage of the patient's exhalations over strong alkalis in a canister The gases, freed of carbon dioxide, are then returned to the mask and are rebreathed

Apparatus The devices employed to accomplish absorption are called filters Filters are of two types

1 The *to and fro filter* which consists of a mask, canister, and rebreathing bag (page 77)
2 The *circle filter* which consists of two tubes, two valves, a mask, a canister, and a rebreathing bag (page 75)

Absorbent Hydroxides of alkali and alkaline earth metals are the only available absorbents Two types are employed

1 *Soda lime* A mixture of sodium and calcium hydroxides This is the most popular and widely employed absorbent (see page 74)
2 *Barium lime* (Baralyme) A mixture of barium and calcium hydroxides This mixture has recently been introduced into anesthesia but is not as widely employed as soda lime

Advantages of Carbon Dioxide Absorption

1 It allows complete rebreathing of exhaled gases *which results in considerable reduction in the cost of anesthesia*
2 It allows complete enclosure of inflammable mixtures and, therefore minimizes the hazard of explosion
3 It allows inhalation of a mixture of nearly constant composition Thus, an even level of anesthesia is maintained
4 It allows the inhalation of warmed gases and vapors
5 It allows the carbon dioxide tension in the alveoli to be maintained at a constant value

Disadvantages

1 The "dead space"* in the mask and connecting pieces is difficult to eliminate and so some carbon dioxide is rebreathed

* Dead space is that space containing gases which are rebreathed without coming into contact with the absorbent and are therefore not freed of carbon dioxide

2 Resistance to inspiration or expiration, or both, may be introduced by valves, tubing, and other parts of the machine or inhaler

Soda Lime

Definition Soda lime is a mixture of sodium and calcium hydroxides moulded into the form of granules It is commonly employed to absorb acidic gases, such as, carbon dioxide

Composition Two varieties of soda lime are available for anesthesia (a) the high moisture type (b) the low moisture type Both are satisfactory The high moisture is more widely employed

The composition of soda lime for anesthesia is as follows

(a) *Low moisture*	
Sodium hydroxide	5%
Water	2% or less
Calcium hydroxide	To make 100%
(b) *High moisture*	
Sodium hydroxide	5%
Water	14–19%
Calcium hydroxide	To make 100%

Necessary Qualities of Soda Lime for Anesthesia

1 It should be non hygroscopic A low sodium hydroxide content insures this feature
2 It should not "cake" Non hygroscopic properties insure this feature
3 It should be of proper size for the filter employed A mixture of granules not larger than will pass through a four-mesh standard screen nor smaller than will pass through an eight-mesh is the most satisfactory size for clinical anesthesia
4 It should be free from alkaline dust and sufficiently hard to prevent fragmentation of the granules Hardness is obtained by adding small amounts of silica

Process of absorption The reaction of absorption is a *neutralization* During the reaction the following phenomena occur

1 Forty-four grams (22 2 liters) of carbon dioxide unite with the alkali yielding sodium carbonate, calcium carbonate, and eighteen grams of water
2 Heat (known as the heat of neutralization) is generated This amounts to 13,700 calories for every forty four grams of carbon dioxide absorbed The temperature of the reacting mass in an 8×13 cm canister during clinical anesthesia in an adult with a normal metabolic rate averages approximately 50–60° C in the to and fro filter and 45–55° C in the circle filter

Absorption Efficiency of Soda Lime

1 Maximum efficiency is secured when the tidal volume is equal to the air space in the charged canister (An 8×13 cms canister averages 425 cc of air space)
2 A charge of 500 grams (one pound) totals an absorption period with intermittent use of 6–7 hours
3 Absorption is more efficient if a charge is used intermittently due to interaction between the sodium and calcium compounds in the granule

Signs of Exhaustion of Absorbent	*Reason*
1 *Absence of heat production* The canister is cold when palpated	The heat evolved during absorption warms the walls of the canister May not be a reliable sign in the circle filter if the canister is inside the inhaler
2 *Elevation of the blood pressure* The pulse rate is not altered to any appreciable extent Pressure returns to normal when absorbent or canister is changed	Excess carbon dioxide stimulates the vasomoter center even under anesthesia
3 *Hyperpnea* If unnoticed or is not pronounced, depression of respiration may be only respiratory sign	Excess carbon dioxide stimulates the respiratory center Depression follows stimulation, the hyperpnea disappears and respiration assumes a gasping quality

The Circle Filter

Description Circle filters consist of a face piece connected to a canister and a rebreathing bag by two tubes of corrugated, non kinking rubber Flutter valves at the inlet and outlet of the canister insure a unidirectional flow of gases over the absorbent (Fig 20, 21)

Features

1 They possess a bypass valve allowing for partial rebreathing and partial or complete absorption of carbon dioxide
2 They possess two canisters with a valve for changing from one to the other or a bypass for rebreathing without absorption Canisters vary in size, but average 500 grams capacity
3 They possess an exhalation valve This may be either at the face piece or at the canister and allows conversion to a semiclosed inhaler
4 They possess an inlet tube which conducts gases from the flowmeter This is usually located at the canister
5 They possess an obturator which is usually placed at the face piece slip joint Obturators prevent loss of mixture from the inhaler
6 They possess a vaporizer for ether or other drugs which may be either

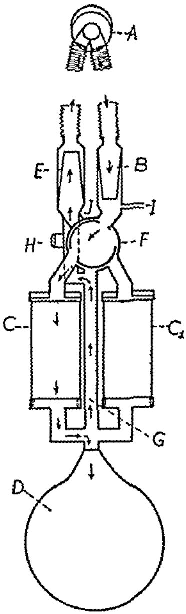


Fig 20 Diagram of a "two canister" circle filter During expiration the gases pass from the (A) mask through the (B) valve through (C) the absorbent in the canister into (D) the bag During inspiration they pass from the bag to (E) the valve, to the mask The unidirectional flow causes them to pass over the absorbent only once (F) The valve allows a shift from canister (C) to (C_1) during course of anesthesia Rebreathing without filtering carbon dioxide is accomplished by adjusting valve (F) allowing gases to pass through (G) the tube into the bag without passing over the absorbent The exhalation valve (H) allows filter to be converted to a semi closed inhaler Gases are admitted through (I) the inlet The ether vaporizer of dropper type may be fastened at (J)

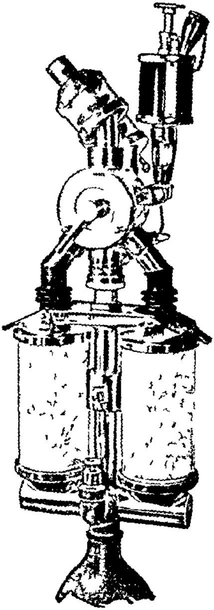


Fig 21 A double canister circle filter (Courtesy of Richard Foregger, Ph D)

of the dropper or wick type It may be placed at the inlet or outlet of the canister

Technique

1 Inflate rebreathing bag with the desired gases
2 Fasten the mask in the routine manner, allowing tubes to the canister to lead off from right side of mask
3 Turn head slightly to right side
4 Turn filter to "on" to initiate absorption of carbon dioxide

Advantages of Circle Filters

1 Alkaline dust is not inhaled because it accumulates in the rubber tubes
2 The inspired air is warmed, but not excessively (31–33° C)

3 A snug application of the face piece is easily secured and maintained, particularly by inexperienced individuals
4 Carbon dioxide is removed gradually after rebreathing, during induction, or at other times over a period of several minutes
5 The air space between the mask and the absorbent in the canister does not act as a "dead space" if the valves function properly
6 The efficiency of the apparatus is not decreased when the tidal volume is less than air space of the canister (this is not so in the to and fro)

Disadvantages

1 They are composed of numerous parts, some of which may become deranged
2 The surface of the tubes, the large canister and the valves create added resistance to respiration
3 The possibility of cross infection, if tubing, valves and other parts are not carefully cleansed, is greater than in the to and fro
4 Absorption efficiency is not as satisfactory as in the to and fro over long periods of time Apparently exhaustion of the absorbent occurs This must be followed by periods of rest to regenerate activity

Comment	*Reason*
1 All tubes should be as wide and as short as possible All apertures should be wider than the trachea	Long or narrow tubes create resistance to respiration
2 Inspect valves frequently for efficiency	Old rubber valves become rigid and useless Metal valves may adhere to parts
3 Cleanse tubes with soap and water between cases	Tubes may be responsible for cross infection
4 Double canisters are desirable	One charge may "rest" without being removed from the inhaler while the other is being used
5 Clamp or screw top of canister tightly after filling	The top is the source of many large leaks

To and Fro Filter

Description The to and fro filter consists of a mask which slips into the inlet of a cylindrical canister The canister in turn slips into the inlet of the breathing bag The exhaled gases pass over the soda lime to the bag During inspiration the flow is reversed and the gases pass from bag to mask The gases, therefore, pass over the absorbent twice (Figs 22 and 7, pages 78, 58)

Features

1 All have a face piece, interchangeable canister, and interchangeable

bag with an inlet nipple for gases and vapors (simplest) (Fig 7, page 58)

2 Some possess an exhalation valve at the slip joint on the face piece or the bag or canister which allows their conversion to a semi closed inhaler if desired (Fig 22)

3 Some may possess an obturator at the face piece which prevents loss of gases during intubations, insertion of airways, etc (Fig 22)

4 Some may have an ether vaporizer, usually of the dropper type, interposed between the face piece and the canister, or the bag and canister (Fig 22)

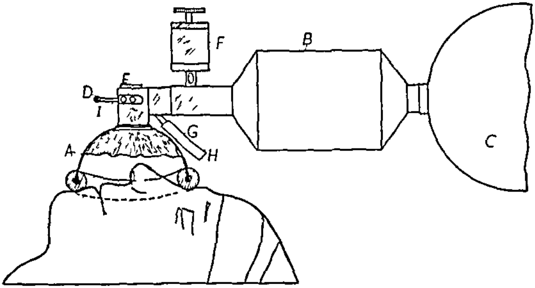


Fig 22 To and fro inhaler composed of (A) a face piece (B) a canister and (C) a breathing bag The unit is complete with (D) the obturator which allows the mask to be closed from the remainder of the inhaler (E) an adjustable exhalation valve and (F) a vaporizer of the dropper type are also provided Gases are admitted into the inhaler through the (G) inlet attached to (H) the delivery tube The patient breathes room air through the (I) vents when obturator is turned on and the inhaler is closed from the mask

Canister Sizes Canisters are usually cylindrical, brass containers with wide inlets averaging 2 5 cms (Fig 23) They vary in size as follows

1 8×13 cms (capacity 500–550 gm) For adult subjects whose tidal volume averages 500 cc The inter- and intra granular air space in the canister, when charged by 4-8 mesh soda lime, averages 425 cc

2 7×12 cms (capacity (350–400 gm) For young adults and subjects whose tidal volume approximates 350 cc

3 6×8 cms (capacity 250–275 gm) For children and subjects whose tidal volume ranges between 100–200 cc

Technique

1 Choose the canister of proper size for patient to be anesthetized The size depends upon the tidal volume of the patient

2 Place a pillow approximately 3" thick under the occiput No other form of support works satisfactorily
3 Blow the dust from the absorbent as follows Hold the palm of the hand tightly over the outlet and blow into inlet of canister Suddenly release palm Repeat several times
4 Apply the mask of the inhaler in the usual manner and hold with left hand Support the canister in the right
5 Induce anesthesia in desired manner As soon as canister is inserted

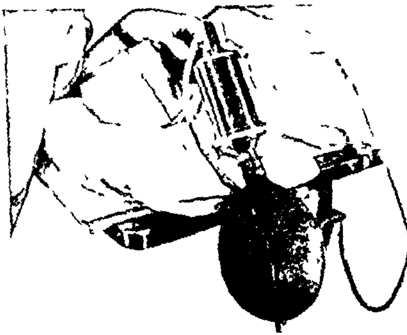


Fig 23 The satisfactory management of the to and fro inhaler requires that the head be supported upon a pillow and inclined to the right The end of the canister rests upon the edge of the pillow and the bag remains alongside the operating table

tilt head towards right side so that the canister end rests on pillow and bag hangs over the right side of operating table (Fig 23)

Advantages of the To and Fro Filter

1 Gases pass over the absorbent twice—during inspiration and during expiration The efficiency of absorption is thereby increased
2 Resistance to respiration is low (2 5–3 *mm* H_2O)
3 The apparatus is relatively simple because it consists of so few parts It is difficult to derange
4 Cross infection is minimized because the parts are easily cleansed
5 Carbon dioxide is quickly removed (45 to 60 seconds) when the filter is introduced into the inhaler after the patient has been rebreathing without it

Disadvantages

1 Inspired gases may be warmed above body temperature (37°–41° C as a rule)

2 Alkaline dust from the absorbent may be inhaled because the filter is next to the face piece The dust causes severe irritation to the respiratory tract
3 A snug fit of face piece is frequently difficult to secure and maintain
4 The apparatus is in the operative field in operations about head or neck
5 As the charge becomes exhausted, the space at the mask end of the canister acts as a "dead space" This "dead space" is quite pronounced if a large canister is employed when the tidal volume is low

Comment	*Reasons*
1 Do not drop canisters	The canister develops leaks at the joints and seams
2 Do not prop canisters with pads, towels, etc	Improperly balanced canisters cause leaks about the face piece
3 Replace the canister with a fresh one approximately every hour even though absorption is proceeding satisfactorily	This prevents overheating of gases Temperature in mask rises to 39–41°C, at the end of an hour
4 Do not wet or moisten soda lime	The porosity of the granules is disturbed and resistance to respiration is increased by wetting
5 Always have a freshly charged canister in reserve	The "used" canister may suddenly become exhausted
6 Always pack canisters tightly	Fragmentation of the granules and dust formation is thereby minimized "Channeling" is also prevented
7 When filling canisters, screen the absorbent if it appears dusty or fragmented	The dust is difficult to remove completely by blowing out the canister if the amount is excessive

Clinical Use of Carbon Dioxide Absorption

The filter should be in use during induction and maintenance of all types of anesthesia in the following circumstances

Circumstance	*Reasons*
1 Diabetes, nephritis, or acidosis from any cause	Carbon dioxide enhances acidosis and should not be allowed to accumulate in the inhaler
2 Cardiac disease	Carbon dioxide causes circulatory disturbances, enhances arrythmias, and increases the respiratory effort
3 Hypertension	Carbon dioxide excess causes an elevation of blood pressure due to stimulation of the vasomotor center

4 Thoracic surgery, respiratory obstruction, dyspnoea, and cyanosis	Carbon dioxide excess may disturb the central control of respiration It stimulates the respiratory center and increases the amplitude of respiration
5 Fever or high metabolic rate	The output of carbon dioxide is above normal in these subjects and an excess may rapidly accumulate in the inhaler if rebreathing is tolerated
6 Cyclopropane anesthesia	Hyperpnea is not necessary to facilitate induction It may contribute to the elevation of blood pressure often observed with this drug
7 Anesthesia for children	Children appear to be more susceptible to effects of excess carbon dioxide than adults
8 Administration of oxygen during spinal anesthesia and other similar circumstances	The respiratory effort is increased and movements of the diaphragm interfere with the work of the surgeon

The filter should not operate in the following instances

Instance	*Reasons*
1 During the induction of ether or nitrous oxide-ether, or ethylene ether anesthesia	The hyperpnea facilitates and accelerates induction by increasing the minute volume exchange
2 When the patient becomes "light" during the maintenance of ether anesthesia	The hyperpnea as well as the anesthetic effect of carbon dioxide itself facilitates the reanesthetization
3 When carbon dioxide is added to the inhaler from the supply cylinder	The soda lime will become exhausted rapidly Both the gas and the absorbent are needlessly wasted

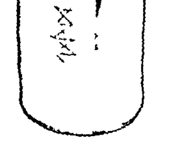


Fig 24 Marking the time sode lime has been used to filter carbon dioxide Each X indicates one hour's use Each portion of the X indicates one quarter hour or fraction thereof

Comment	*Reasons*
1 The filter should be turned on slowly and gradually if carbon dioxide is allowed to accumulate during induction of anesthesia	Carbon dioxide possesses anesthetic properties Patient may "lighten" and often cough if it is removed too rapidly if patient is not deep

2 Always record the time a charge of soda lime is used at the end of each case (Fig 24)	The record provides an index of the state of the absorbent so that long operations will not be started with almost completely exhausted canister

REFERENCE

Adriani J The Chemistry of Anesthesia Pp 72–104, Charles C Thomas, Springfield Ill, 1944

B TECHNIQUES OF INHALATION ANESTHESIA

PREPARATION FOR INHALATION ANESTHESIA

The anesthetist should complete all preparations for anesthesia well in advance of the operating time to avoid delaying the surgical team

His duty is to

1 Assemble all necessary equipment and to be positive that the following details are in order
   a Each cylinder on the machine should contain an adequate supply of gas
   b The reserve oxygen cylinder should be full
   c The inhaler should be complete in all its parts and there should be no leaks
   d An adequate supply of each anesthetic agent or gas should be on the machine or within immediate reach
   e The soda lime should be fresh or, if only partially exhausted, a freshly charged reserve canister should be available
   f The desired type of artificial airway should be within reach
   g The suction apparatus should be in working order and available for instant use
2 Examine the chart, check the identity of patient, contemplated operation, signature for permission for operation, report of the examination of the heart and lungs, urine report, and whether or not premedication has been given
3 Arrange the patient, machine, and other equipment as shown in Fig 25
4 Remove loose dentures, bridges, and other objects which may cause obstruction to respiration or which might be aspirated
5 Loosen gown and all bandages or tight dressings on thorax or neck Remove gown for thoracic operations
6 Apply blood pressure apparatus (page 54) and intercoupler to patient
7 Apply leg strap and wrist cuffs loosely Fasten them at time of induction, but not so tightly as to embarrass circulation in the extremities
8 Dim glaring lights and turn off those which are directed toward the patient Talking and loud noises should be avoided until patient is anesthetized

9 Request an attendant, nurse, or a member of the surgical team to remain in the anesthetic room during the induction period

Comment	*Reasons*
1 Do not anesthetize patients on stretchers, rollers, in bed, or in situations in which one cannot cope with emergencies instantly	The "head down" position so necessary in the event of emesis is difficult to secure on rollers or in bed Fire hazards are usually greater in such circumstances

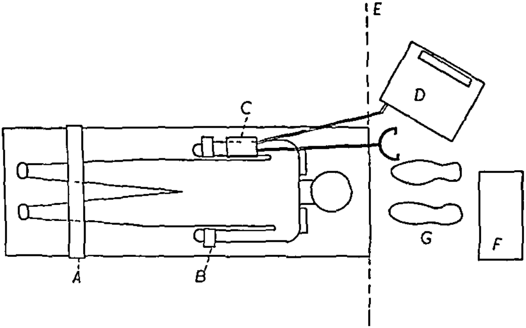


FIG 25 General arrangement of the patient and anesthesia apparatus The patient is placed upon the table in the center of its long axis The (A) strap is adjusted above the knees The arms are secured by means of (B) wrist cuffs The (C) blood pressure apparatus is adjusted to the right arm The (D) anesthesia apparatus is placed on the right side beyond the line of the (E) end of the table (F) Suction apparatus is within ready reach of the (G) anesthetist

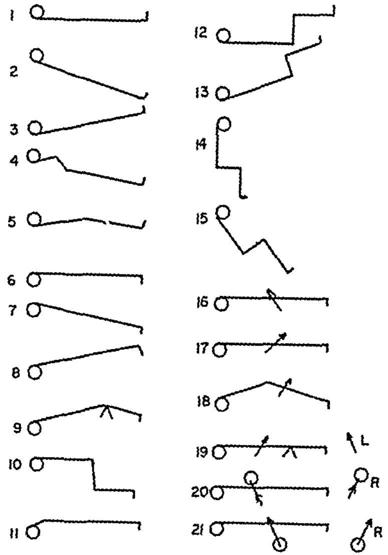
2 Do not anesthetize patients in the operating room if special anesthesia rooms are available	Quiet surroundings contribute to the tranquility of both the anesthetist and patient
3 Do not anesthetize any patient who does not have properly applied restraints	Many patients exhibit remarkable strength during excitement stage and may suffer injury
4 Do not anesthetize any patient unless an attendant is present as an assistant	The attendant may help restrain the patient A second person should be present for protection of the anesthetist from a medicolegal standpoint

Positioning the Patient

1 The position that least possibly interferes with respiration is the supine
2 Arms should be along side of the patient If out on an arm board they should not be abducted beyond 90°

TABLE V

TERMINOLOGY FOR POSITIONS OF PATIENTS ON OPERATING TABLE*



1 Supine
2 Supine head up (Fowler s)
3 Supine head down (Trendelenburg)
4 Supine head up—neck flexed—(Thyroid)
5 Supine lumbar lift (gall bladder)
6 Prone
7 Prone head up
8 Prone head down
9 Prone—pelvis lift
10 Prone—thighs flexed
11 Prone—head flexed (Cerebellar)
12 Lithotomy supine
13 Lithotomy head down
14 Sitting
15 Semi-sitting
16 Lateral—left supine
17 Lateral—right supine
18 Lateral flexed
19 Lateral lumbar lifted (Kidney)
20 Lateral left head elevated
21 Lateral right head down

* Symbols in diagram above may be used to designate position if desired

3 The arms should not hang over the edge of the table otherwise injury to the radial and other nerves may result

4 When Trendelenburg position is used place knees slightly below break in the table Lower foot of table and support body by calves

5 Shoulder braces should be well padded Do not allow shoulder braces to bend medially, where brachial plexus may be injured

6. When prone position is used place pads at symphysis, anterior superior spines and shoulders to minimize pressure
7. Steep Trendelenburg, prone and extreme lithotomy position may cause severe circulatory depression or interference with respiration
8. Lateral flexion of patient may interfere with adequate ventilation
9. Elevation of gall bladder bars in the prone or lateral position may cause precipitous drops in blood pressure
10. Changing from prone to supine position may cause drops in pressure
11. Blood pressure may fall when legs are lowered from lithotomy position

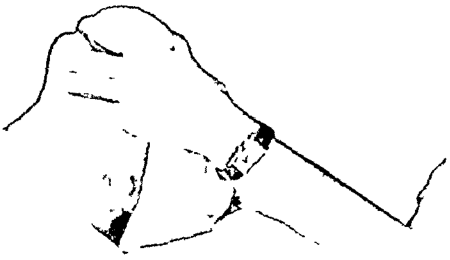
Application of Masks and Inhalers

Masks should be snugly applied and firmly held to the face for successful inhalation anesthesia by the closed method Masks for anesthesia by the drop method are held in the same manner as for the closed system Consequently, the majority of the remarks below apply to all types of masks

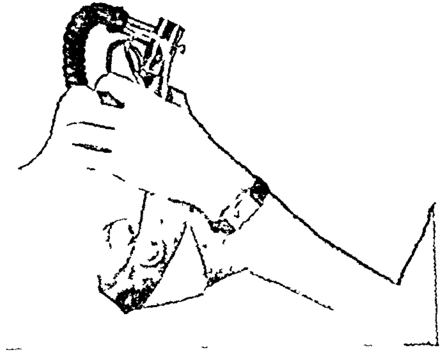
Procedure	*Reasons*
1 Select a mask which fits the patient's face snugly	A snug fit is necessary for successful inhalation anesthesia The mask is the source of 90% of the leaks in the closed system
2 Center the headband under the occiput The retaining hooks should be in line with the prongs on the mask	Leaks result if the mask is not properly applied
3 Cover the eyes with a thin flat piece of moistened cotton	This protects the conjunctiva from mask and secretions from the mouth
4 Ventilate apparatus by filling and emptying the breathing bag several times with oxygen until all odors of previously employed gases or vapors are dispelled	Extraneous gases or vapors, particularly ether, may cause excitement or coughing
5 Warn patient as mask is being applied to the face Allow him to breath through it with obturator closed Request that patient breathe in a normal manner	The patient cannot see movements of the anesthetist because he stands behind the patient Sudden movements and unexpected maneuvers may cause excitement in apprehensive subjects
6 Grasp the mask in the left hand so that the thumb rests along margin at its back, the second digit on the front (Fig 26)	This grasp permits distribution of pressure to proper points on face to maintain a snug fit
7 Wrap the third, fourth, and fifth digits around the chin, below the	This grasp allows traction to be made on the chin to maintain a

mandible, and extend chin so that it points directly upward (Fig 26)	free airway
8 Distribute the forearm along the left side of the head and rest elbow on the table (Fig 23)	The forearm does not become tired in this position
9 Add 600 or 700 cc of oxygen or gas mixture to the inhaler and start the flow of mixture	The patient should never be permitted to breath from an empty inhaler
10 Explain to the patient that he may feel the mask pressing tightly on his face for a few minutes	Reassuring the patient establishes confidence in the anesthetist and avoids excitement
11 Adjust the right strap of the headband to the mask and then the left *Adjust the right side first*	Breathing tubes and canister are connected on the right side of the mask Therefore this side is more difficult to fasten if the left side is fastened first
12 Turn the head slightly to the right as soon as the patient is in stage III	a The "head on the side" position allows mucous and other secretions to gravitate to the side of the mask and not backward b This position is necessary to correctly balance the canister in the to and fro system

Comment	*Reasons*
1 Always select the mask of smallest capacity particularly for children	Minimize "dead space" as much as possible The tidal volume of children is relatively small These subjects therefore may rebreathe the contents of a large mask over and over again
2 The pointed end (narrow) of the mask should be placed over the bridge of the nose	The wide portion of the mask is intended to fit over the mouth
3 Hold all masks with the left hand Never use both hands	The right hand should remain free for other manipulations
4 Always wipe the mask dry and be certain it is free from odors before applying it to the patient's face	Wet masks are uncomfortable and annoy the patient They may contribute to the formation of pressure marks
5 If a patient is extremely apprehensive, hold mask lightly and touch him as little as possible until he passes into stage III	Tight feeling of the mask about the face may further stimulate the patient and cause excitement in stage II
6 In edentulate persons, insert the pharyngeal airway, then pad	The mask may be applied more satisfactorily if the cheeks and an



a



b

FIG 26a and b Techniques for holding masks The thumb and index finger of the left hand hold the mask firmly to the face the remaining three fingers maintain the airway by supporting the chin and jaw The same technique applies to holding both open and closed masks Closed masks must be held regardless of the fact that they are secured by head bands Note that the Yankauer mask in Fig 26a is entirely open and the gauze trimmed to fit the edges Towel and superfluous gauze contribute to the obstruction to respiration

cheeks with a gauze pack in each side of the mouth	gles of mouth bulge outward
7 During long operations, loosen the mask at least once every hour	Tight headbands frequently interfere with the circulation to the forehead and scalp
8 At termination of anesthesia, re-	It may become soiled if post anes

	move the headband from beneath the occiput as soon as the mask is disconnected	thetic emesis occurs
9	Do not clean masks (or other rubber appliances) with lysol, creosol, or other necrotizing disinfectants	The chemical soaks into the rubber and may burn the face

Judging Depth of Inhalation General Anesthesia

Anesthesia affects all the physiological systems of the body to some degree However, the anesthetist relies chiefly upon certain physical signs and symptoms in the following three systems as guides to the status of the patient and depth of narcosis

1 The central nervous system The behavior of superficial and deep reflexes and muscle tone are observed The eyes, because they are accessible and have reflexes which undergo graded changes, are used as a guide
Lid reflex The presence of voluntary control of the eye lid is noted
Ocular motion Position and movements of the eye balls in response to stimulation by light are noted
Pupillary change Size and response to light are observed
2 The respiratory system Respiratory rate, tidal volume, character of inspiration and expiration, and intercostal and diaphragmatic activity are observed continuously
3 The circulatory system Rate and volume of pulse and variations in blood pressure are noted at intervals (see page 51)

Inhalation General Anesthesia Is Divided into Four Stages

Stage I Analgesia From the beginning of the administration of anesthesia to the beginning of loss of consciousness Use of this stage is limited to obstetrics, dental extractions, and other superficial operations

Stage II Delirium From the loss of consciousness to the loss of the lid reflex This stage is of brief duration and is often unnoticed in well premedicated subjects It may be of long duration and accompanied by marked excitement in apprehensive, unpremedicated subjects, and alcohol addicts No well demarcated line of transition exists between stages I and II

Stage III Surgical From the loss of lid reflex to cessation of respiratory efforts This lack of respiratory effort must be due to the effect of the drug Surgery is performed in this stage The zone is wide and for the sake of convenience is divided into four strata called planes *

Stage IV Overdosage From cessation of respiratory efforts to circulatory failure Death supervenes unless artificial respiration is instituted immediately to supply oxygen and remove the excess drug from the alveoli and blood

* Indicate stages by Roman numerals and planes by Arabic numerals Thus the fourth plane of third stage is stage III, plane 4

Signs in the Three Systems

	Nervous System	Respiratory System	Circulatory System
First Stage	1 Reflexes remain active but sensation to pain is diminished or lost 2 No changes occur in eye reflexes ocular movements or pupillary size 3 Muscle tone is unchanged 4 The subject remains conscious and aware of his surroundings	1 Normal—No change occurs in rate or amplitude of respiratory movements	1 No change occurs in the rate or character of the pulse 2 Blood pressure is not changed if subject is not apprehensive
Second Stage	1 The cerebral cortex is depressed and consciousness is gradually lost 2 Muscle tone increases and rigidity usually appears 3 Superficial reflexes are active and may be exaggerated or hyperactive (react to stimulation of skin) 4 Excitement as characterized by semi voluntary struggling singing crying loud talking It may appear or be precipitated by stimuli on touching the patient 5 Pupils may dilate react to light and possess a regular outline 6 Eyeball movements remain active but voluntary control gradually disappears Occasionally, pupils are eccentrically placed 7 *Voluntary control of lid is retained* (when lid is touched patient closes eye voluntarily) 8 Ability to vomit cough and swallow persists	1 Respiratory rate and rhythm are irregular Apprehensive subjects may breathe deeply or hold their breath Acapnia from deep breathing may produce brief periods of apnea 2 Intercostal muscles and di*aphragm remain active*	1 Blood pressure may rise from excitement. 2 Pulse rate increases due to excitement and probable sympathetic stimulation
Third Stage Plane 1	1 Lid reflex ' is inactive (tone as well as voluntary control of the lid disappears) 2 Superficial reflexes are obtunded (active stimulation of the skin) 3 Eyeballs are active When the lids are lifted both move synchronously in a horizontal plane (occasionally motion may be vertical) The motion is preceded by a latent period of inactivity of several seconds The reflex soon becomes obtunded and the motion ceases but reappears if the lids are closed to exclude light momentarily and then reopened	1 Respiratory rhythm becomes regular and automatic 2 Amplitude remains unchanged with some drugs (ether) 3 Intercostal muscles are active 4 Full diaphragmatic activity is present 5 Inspiration and expiration are of approximately equal duration The thorax expands as diaphragm expands	1 Blood pressure and pulse rate gradually return to preanesthetic levels from relief of excitement unless altered by other factors such as anoxia carbon dioxide excess premedication trauma etc

Signs in the Three Systems—(Cont)

	Nervous System	Respiratory System	Circulatory System
	4 Pupils revert to preanesthetic size 5 The reflex in the pharynx disappears and the patient usually tolerates a pharyngeal or nasal airway without retching coughing or swallowing 6 Muscle tone decreases but relaxation is not sufficient for abdominal surgery		
Plane 2	1 Eyeballs become progressively less active and finally are centrally fixed as the lower border of this plane is attained 2 There is a slight increase in size of pupils as compared to plane 1 3 Corneal reflex is gradually obtunded 4 Laryngeal (glottic) reflex disappears or is obtunded 5 Muscle tone decreases and relaxation is improved	1 Intercostal muscles are still active 2 Inspiration is quickened expiration slightly prolonged 3 Interrespiratory pause is lengthened 4 Thorax still expands as diaphragm contracts	1 No noteworthy change occurs in blood pressure or pulse rate unless modified by other factors such as trauma shock hypercapnia etc
Plane 3	1 Eyeballs remain fixed as in plane 2 Dilatation of pupils is more pronounced Light reflex becomes progressively obtunded 2 Muscle tone is decreased markedly Relaxation of abdominal muscles is usually sufficient for surgery	1 Intercostal muscles are paralyzed progressively from above downward 2 Rocking motion of the thorax gradually becomes apparent 3 Inspiration is quickened expiration prolonged more than in plane 2 4 Interrespiratory pause is prolonged further 5 Thorax and intercostal muscles may retract as diaphragm contracts	1 No alteration in either blood pressure or pulse rate occurs unless modified by other factors such as trauma, shock anoxia etc
Plane 4	1 Eyeballs remain centrally fixed 2 Pupils dilate widely, become irregular and do not react to light Conjunctiva may have a glassy appearance 3 Flaccidity of muscles and other tissues occurs 4 Bronchial reflexes obtunded	1 Respiration is maintained almost entirely by the diaphragm It may be characterized by a gasping type inspiration, prolonged period of expiration and a long pause at end of expiration 2 Decreased ventilation may cause cyanosis	1 Blood pressure decreases 2 Pulse pressure decreases 3 Pulse rate increases volume decreases
Fourth Stage	1 There is absence of all reflex activity 2 There is complete flaccidity of tissues 3 Pupils are widely dilated 4 Sphincters are relaxed	1 Failure of respiratory movements is due to medullary depression 2 Cyanosis is frequently but not always observed	1 Circulatory failure follows respiratory failure unless artificial respiration is instituted

The above table merely serves as a general guide to the depth of anesthesia by currently employed inhalation anesthetics drugs Variations occur with each agent or in using the same agent and another technique of administration These are described under the discussion of individual techniques Variations frequently occur in different individuals However a certain group of signs persist for a particular individual throughout anesthesia The following factors may cause considerable modification of many of these signs

Anoxia Dilatation of pupils, vomiting, rigidity of muscles, and an elevation of blood pressure are common sequelae

Respiratory Obstruction The character of respiratory movements, intercostal and diaphragmatic activity are altered

Hypercapnia Character of respiration is modified by the accompanying hyperpnoea or respiratory depression Elevation of blood pressure invariably occurs

Increased Intracranial Pressure Pupillary signs are modified Eye reflexes, pharyngeal and laryngeal reflexes are frequently obtunded

Reflex Stimulation Traction reflexes may contribute to laryngeal spasm, coughing, retching

Age of the Patient Pupillary activity decreases with age and is often not a reliable guide after the fifth decade Pupillary size is subject to greater variation in children Reflex activity decreases with age

Status of Patient Reflexes persist for a longer period in robust subjects than in the weak and infirm Frequently, they are obtunded in debilitated, comatose, or cachectic subjects

Non-Volatile Drugs Superficial and deep reflexes are obtunded as a rule by non volatile drugs Ocular reflexes and movements are unreliable when drugs such as avertin, pentothal and barbiturates of a similar type are employed for narcosis or as the sole agent

Comment	*Reasons*
1 Size of pupils is not always a reliable guide to depth of anesthesia, and is of little significance in stage III unless they are dilated	Pupillary size is modified by the opium and belladonna alkaloids employed for premedication The effects of the combination are unpredictable
2 Signs often reappear in different sequence in the ascent from stage IV to I during recovery, than in the descent from stage I to IV	Certain signs, therefore, may not be reliable guides to changes in depth during maintenance of anesthesia
3 The patient should not be prepared, moved, or disturbed in any manner before the lid reflex disappears (patient is in stage III)	Avoid excitement as struggling may ensue under such circumstances if stage II has not been traversed

4 Tilt the mask forward and away from the eyes when observing pupillary and other eye reflexes	The pressure on the eyes, which may obscure the signs, is thus released without loss of mixture from the inhalator
5 Examine both eyes simultaneously in studying ocular movements and reflexes	Although eyes oscillate synchronously in stage III they may not always do so in other stages
6 When doubt exists regarding activity of ocular signs allow the eyes to close momentarily to exclude light and then reexamine them	The oscillation reflex "wears off" after lengthy exposure to light, but reappears after a few seconds rest in the absence of light
7 Never judge depth of anesthesia by determining the activity of the corneal reflex	Ulceration often results from even the gentlest stimulation of the cornea
8 Cyanosis or "color" should never be an index of depth of anesthesia	Cyanosis merely indicates anoxemia It may appear during light or deep anesthesia
9 When several signs are characteristic of a certain plane they do not necessarily appear simultaneously or with equal rapidity	Signs vary in onset according to the mechanism which produces them and the degree of saturation of tissues by the agent employed

Depths of Anesthesia Desired for Various Types of Surgery

1st plane Incision and drainages of superficial abscesses, superficial operations on skin, plastic surgery, suture of tendons of small muscles, mastectomy, mastoidectomy, thyroidectomy, craniotomy, reduction of fractures of small bones, and normal obstetrics

2nd plane Surgery of the large bones, gynecological, urological, and perineal operations, tonsillectomy and other pharyngeal surgery, thoracic surgery, hernioplasties, amputations, laminectomies, operative obstetrics, lower abdominal and eye surgery

3rd plane Upper abdominal surgery, ventral hernioplasties, rectal surgery, intratracheal and intra laryngeal surgery, obstetrical surgery requiring relaxation of the uterus

4th plane Not employed under any circumstances

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Ether Anesthesia

Description Ether is a volatile inflammable liquid whose vapor possesses marked narcotic potency, a pungent odor, and is highly irritating to the mucous membranes

Uses

1 For surgery of all types particularly that requiring relaxation of muscles
2 For fortifying mildly potent anesthetic drugs
3 As a complemental agent to basal narcosis obtained from drugs such as avertin, various barbiturates, or morphine

Cost Relatively inexpensive (approximately 90¢ per lb)

Concentration

(a) For surgical anesthesia approximately 4% by volume in the alveoli
(b) For respiratory failure approximately 8% by volume in the alveoli

Premedication Morphine and scopolamine or morphine and atropine in standard doses (see premedication page 39)

Methods of Administration

1 *By open masks* With air as a vehicle
2 *By semi open mask* With air or oxygen as a vehicle
3 *By insufflation* With air or other gases as a vehicle
4 *By semi closed or closed inhaler* With oxygen or other gases

Induction of Ether Anesthesia Induction is prolonged because of the irritating effects of ether (Fig 27) In order to simplify and shorten the induction period the patient is anesthetized with a non irritating rapid acting drug Under this narcosis the anesthetic concentration of ether is attained as rapidly as possible The first and second stages of ether anesthesia are thereby shortened (Fig 39)

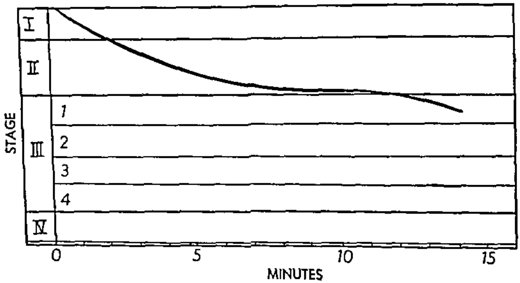


Fig 27 Curve showing the rate of transition through the stages of anesthesia during the induction period using ether by the "open drop technique" The high air blood ratio the irritating qualities and its comparatively high solubility in water are responsible for the prolonged period of induction which ether requires

The following are some common methods of induction

1 Nitrous oxide oxygen induction, ether vapor and nitrous oxide oxygen sequence by the semi closed method
2 Nitrous oxide oxygen induction by semi closed method, ether oxygen sequence by the closed method
3 Ethylene oxygen induction, ether vapor and ethylene oxygen sequence by the semi closed method
4 Ethylene oxygen induction, by semi closed method and ether vapor oxygen sequence by the closed method
5 Cyclopropane induction by the closed method, ether oxygen sequence by the open or closed method
6 Vinethene induction by the open method, ether vapor sequence by the open method
7 Ethyl chloride induction, by the open drop method, ether vapor sequence by the open method
8 Avertin or other types of basal narcosis, followed by any of the above methods of induction and ether sequence
9 Chloroform induction, ether sequence by either the open or closed methods

Advantages of Ether

1 It is a potent agent useful for all types of surgery
2 It possesses a wide margin of safety
3 It is relatively inexpensive
4 It is chemically stable and easily preserved
5 It may be administered with very simple apparatus if necessary
6 It may be administered by inexperienced individuals under surveillance of an experienced anesthetist in emergencies
7 It allows the use of air as a diluent and source of oxygen because the concentration required for anesthesia is low
8 It does not affect circulation appreciably at the levels of anesthesia usually employed for surgery
9 It tends to stimulate respiration rather than depress it

Disadvantages of Ether

1 The period of induction is slow, prolonged, unpleasant, and often accompanied by excitement
Recovery is slow, particularily after long operations, because tissues absorb a large amount of the agent and desaturation is slow
3 It is inflammable and therefore cannot be used with safety in the presence of cautery, x ray units, or nonspark proof electrical equipment
4 It is irritating to respiratory passages and causes coughing secretion of mucus, and salivation

5 It disturbs important metabolic functions Liver function, acid base balance, and carbohydrate metabolism are affected particularly

6 Nausea common

Contra Indications to Ether	*Reasons*
1 Acute or chronic infections of the upper or lower portions of the respiratory tract (pulmonary tuberculosis, active or latent)	Secretions may assist the spread of infection from one portion of the respiratory tract to another
2 Diabetes, or acidosis from any cause	Elevation of blood sugar and lowering of carbon dioxide combining power accompany anesthesia even though the duration is short
3 Nephritis, renal insufficiency	Transient decrease in renal function accompanies and follows anesthesia
4 Decreased liver function, diseases of the liver, jaundice	A transient decrease in liver function accompanies and follows anesthesia
5 Diseases or injuries to the brain accompanied by increased intracranial pressure	Increased intracranial pressure accompanies anesthesia, particularly in the presence of anoxemia or carbon dioxide excess

Ether by the Open Drop Method

Principle Ether is dropped on a gauze held away from nose and mouth of the subject so that it may be readily vaporized, mixed with air, and inhaled

Uses

1 For surgery on children and young adults
2 For anesthesia which must be administered by inexperienced individuals or in the absence of adequate apparatus
3 As a preliminary to ether by insufflation methods
4 As a necessity in the event other agents or equipment for their administration are not available or impractical

Concentration

1 Surgical anesthesia approximately 4% by volume in the alveoli
2 Respiratory failure approximately 8% by volume in the alveoli

Premedication

1 Morphine and scopolamine, or morphine and atropine, in standard doses (see premedication)

Apparatus

1 Wire mask Yankauer, Ferguson, or other type (Fig 28)

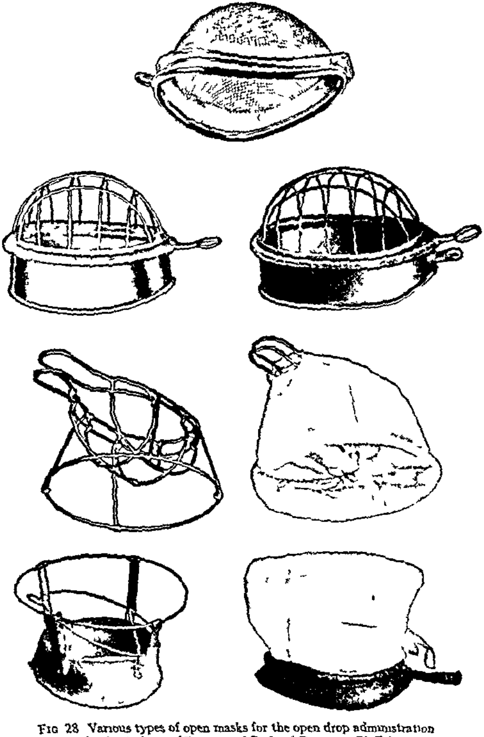


FIG 28 Various types of open masks for the open drop administration of volatile drugs (Courtesy of Richard Foregger Ph D)

2 6–12 layers of gauze or stockinet to cover mask
3 Pharyngeal airway of size required for the subject
4 One eye protector consisting of a piece of rubber dam to cover both eyes
5 Mineral or castor oil for eyes (The castor oil must not be rancid)
6 Two surgical towels

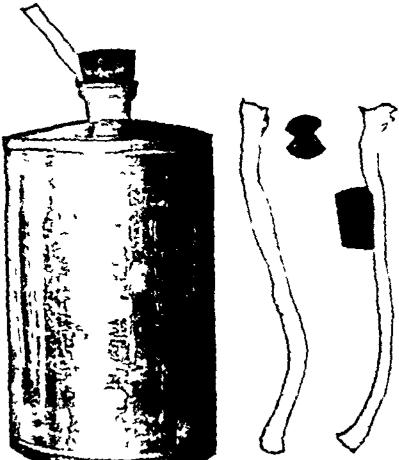
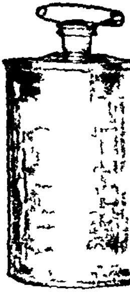


FIG 29 The original container may be improvised as a dropper by cutting two longitudinal wedges in a cork and placing it in the opening of the can A wick of rolled gauze passes through one wedge, the other acts as a vent.

7 Suction apparatus, tubing, and metal pharyngeal tip (Fig 85)
8 Container of ether (¼ or ½ lb) arranged to act as a dropper (Figs 29, 30)
9 Vaseline to lubricate eye protector and skin

Technique



1 Prepare mask, ether dropper and lubricate one side of the eye protector (with Vaseline Petroleum Jelly) in the desired manner
2 Arrange patient in usual manner described for inhalation anesthesia Apply blood pressure cuff, leg strap, and wrist cuff in routine manner
3 Cover eyes with protector and drape the forehead and eyes with a folded towel

FIG 30 The original container may quickly be converted into a dropper by piercing the soft metal top with a large safety pin and enlarging the holes to adjust the rate of flow

4 Apply mask to face Hold in same manner as other masks (see holding masks and Fig 26)
5 Allow ether to flow at the rate of one drop every three or four seconds at first and gradually increase to as fast a rate as patient tolerates vapor
6 Continue dropping the ether as rapidly as necessary to maintain the desired depth of narcosis

Signs of Anesthesia The signs of anesthesia are identical to those described under Judging Depth of Inhalation Anesthesia (page 88)

Advantages of Ether by the Open Drop Method

1 The dead space in mask is small (important in children)
2 No elaborate apparatus is required
3 Air may act as the source of oxygen

Disadvantages of Ether by Open Drop Method	*Reasons*
1 Induction period is long and disagreeable to the patient, averages 10–15 minutes whether or not the anesthestist is experienced	The drug possesses irritating properties and high air-blood distribution co efficient
2 Desired depths of anesthesia are difficult to maintain at a constant level	The rate of vaporization fluctuates with changes in respiratory volume and the temperature of the mask
3 The escaping vapors create a fire hazard	It is impossible to confine the vapors
4 Disturbances in carbon dioxide tension in the lungs are frequent	Hyperventilation from respiratory stimulation may cause a decrease of carbon dioxide in the alveoli
5 It is wasteful and expensive	The major portion of the ether escapes into the air Closed methods are more economical
6 Vaporization is not adequate to maintain anesthesia in most adults, particularly in warm climates	The semi-open method must be employed in these circumstances (page 100)
7 Cold ether vapor is inhaled	This may enhance secretion of mucus and may lower body temperature
8 Mild anoxemia is not uncommon	Oxygen in the air is diluted by the ether The tension in the alveoli is thereby reduced

Complications

1 Excess mucus secretion Commonly occurs in poorly premedicated

subjects Some mucus forms during induction regardless of premedication Administer atropine or scopolamine before anesthesia to minimize secretions

2 Laryngeal spasm Usually appears early during anesthesia from strong concentrations of ether or is initiated by mucus in the larynx or pharynx
3 Overdosage Occurs after anesthesia is well established Rare during the induction period unless the patient is non resistant from debilitation, shock, coma, etc
4 Conjunctivitis Ether, blood, or secretions may pass into the eye as result of careless technique
5 Blistering of the skin Caused by a combination of ether, moisture, and pressure applied over an area of skin

Comment	*Reasons*
1 Drop ether slowly at first and increase rate gradually, steadily, and as fast as patient tolerates the vapor	If concentration of the vapor is increased too rapidly, spasm, mucus, and coughing invariably result
2 Turn the head to one side after patient has passed into stage III	Mucus and saliva collect at the side of the mouth and do not flow over face into the eyes
3 If coughing occurs during the induction period, or concentration of ether is increased too rapidly, lift mask momentarily and replace it after the patient takes several breaths of air	The concentration in the pharynx is diluted by this maneuver and spasm is avoided
4 Replace wet mask covers with dry gauze	Water vapor from the lungs condenses on the cold mask Vaporization is retarded and obstruction to respiration is increased by wet gauze
5 Do not apply traction to chin or lower jaw while patient is conscious during induction (stage II and stage I)	Such stimulation precipitates excitement which ordinarily can be obviated
6 Do not cease dropping ether if patient becomes excited Continue the administration as rapidly as it is tolerated	The excitement stage will be prolonged or the patient may pass back into first stage if administration is halted The object is to increase the concentration and pass into stage III as soon as possible
7 Do not wrap towels about the mask when anesthetizing children	Excess carbon dioxide may accumulate and symptoms of carbon

unless absolutely necessary and then only loosely	dioxide excess develop
8 Use the suction freely and remove all secretions as often as necessary	A patent airway must be maintained Incidence of postanesthetic complications is increased when secretions are excessive
9 Increase and decrease dropping of ether gradually and administer it continuously during maintenance	A constant concentration of ether vapor is necessary under the mask to maintain a proper alveolar tension for the desired plane of anesthesia
10 If signs of suboxygenation appear, insert a nasal catheter into one nostril—administer oxygen at the rate of 500 cc or more per minute	When air alone is a vehicle for the vapor, the oxygen tension may be reduced

Ether by the Semi Open Method

Principle

1 The technique and principle are similar to the open drop method except that ether vapor is confined by wrapping a towel about the mask Some degree of rebreathing thereby is instituted (Fig 31)

Uses

1 When vaporization by the open method is inadequate
2 In warm climates when vaporization proceeds rapidly

Technique

1 Same as for ether by open drop with the exception that a towel is wrapped about the mask in a chimney like fashion

Advantages

1 It allows a greater concentration of ether to be inhaled than by the open method
2 It is the only satisfactory method of obtaining anesthesia in an adult by the drop method

Disadvantages

1 Rebreathing may increase carbon dioxide tension to undesired and perhaps dangerous levels
2 Oxygen tension is decreased by interference of ventilation by the towel
3 The possibility of overdosage is increased
4 Hyperpnea from carbon dioxide excess often exaggerates abdominal movements and handicaps the surgeon

Comment	*Reasons*
1 Always begin administration by the open method and gradually wrap towel about mask as anesthesia progresses	Rebreathing from outset may cause patient to struggle and cough because the concentration of ether is too strong
2 The towel should be applied in a chimney like fashion about the mask.	Ether vapor is heavier than air and will thus be confined over the mask
3 The top should be opened widely and the entire mask should form the floor of the enclosure (Fig 31)	This allows free passage of carbon dioxide and oxygen through the mask
4 Do not cover any portion of the mask with the towel	Obstruction to respiration results
5 Always administer oxygen with nasal catheter under mask (1–1½ liters per min)	Prevents anoxia Minimizes excitement

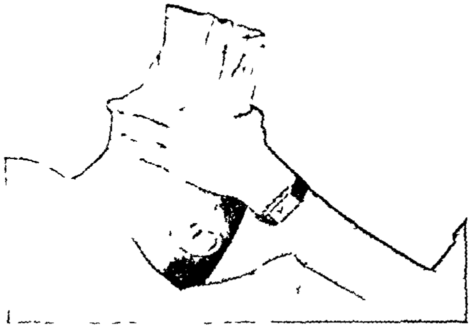


FIG 31 Semi-open technique of anesthesia by the drop method Note that the towel is arranged in a chimney like fashion about a Ferguson mask.

Ether by Insufflation

Principle

1 A current of air, of oxygen, or a mixture of nitrous oxide or ethylene and oxygen is propelled over the surface of liquid ether or through it in the form of fine bubbles, and the mixture of gases and vapor is conducted into the nose or mouth and trachea through a tube or cannula

Types

1 *Intranasal insufflation*

The mixture is conducted into the oropharynx by a single or double nasal catheter (Fig 32a)

2 *Intraoral insufflation*

The mixture is conducted into the oropharynx by a cannula or "ether hook" placed in the mouth (Fig 32b)

3 *Intratracheal insufflation*

The mixture is conducted into the trachea by inserting a lubricated

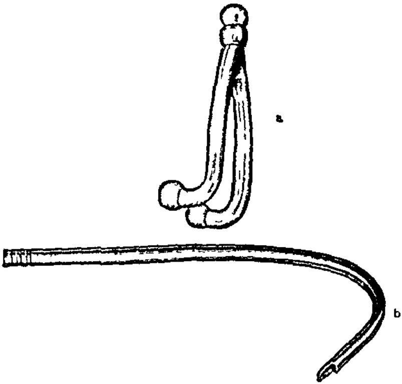


FIG 32 (a) Nasal piece for nasopharyngeal insufflation of anesthetic gases and vapors (b) Ether hook for oral insufflation of anesthetic ga es and vapors (Courtesy of Richard Foregger Ph D)

catheter into the lumen of an intratracheal tube (see artificial airways, page 157)

Uses

1 For operations about the head or face, pharynx, larynx, trachea, or esophagus

Premedication

1 Morphine and scopolamine, or morphine and atropine, in standard doses (same as for open ether)

Materials

1 Ether vaporizer and connecting tubes
2 Mechanical air compressor or other source of compressed gas
3 Reducing valve if cylinders are used as a source of gas
4 Nasal catheters 14–18 F The size varies with the subject (if intranasal insufflation is to be employed)
5 "Ether hook" (if oral route is contemplated) (Fig 33)
6 Vaseline to lubricate the catheter (nasal route)

Technique (Oral)

1 Test the vaporizer and place it in a convenient position which in no way interferes with the surgical team
2 Anesthetize the patient with ether by open drop technique and attain the level of anesthesia desired to complete the operation
3 Commence vaporization of ether Be positive the mixture is flowing through the cannula or catheter Test the flow of gas by holding the cannula against palm of the hand or by cautiously smelling for ether
4 Remove mask and immediately insert hook or cannula into the mouth
5 Suction pharynx if secretions are present
6 Proceed as described under "open drop" technique for signs of anesthesia, maintenance of airway, and precautions

Technique (Nasal)

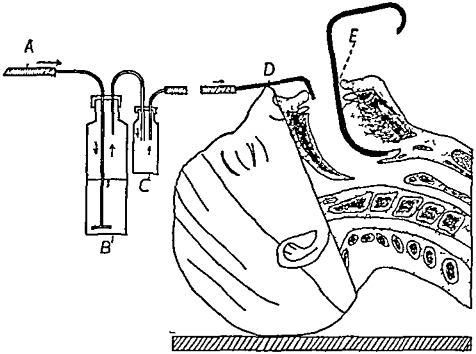
1 Anesthetize patient as described under *Oral Insufflation*
2 Mark off a distance equivalent to the distance between the ala of nose and tragus of the ear on the catheter
3 Commence the vaporization of ether and insert the well lubricated catheter the measured distance into the nostril

Advantages of Insufflation

1 "Dead space" is minimal or negligible
2 It may be employed when intratracheal anesthesia is not feasible, practical, or desirable for oropharyngeal surgery and operations about head, face, or neck

Disadvantages

1 Airway is frequently maintained with difficulty particularly if the head is not accessible to the anesthetist
2 The quantity of ether vapor delivered by the vaporizer is frequently insufficient to maintain anesthesia for adults
3 The air ether mixture is an explosive and a fire hazard
4 The method is wasteful and expensive



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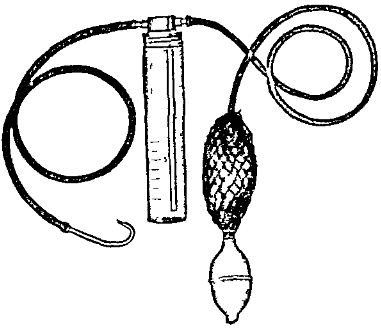

b

FIG 33 (a) Diagram illustrating oral insufflation of volatile liquids (A) Source of compressed gas usually air or oxygen (B) Jar containing volatile liquid. (C) Trap to prevent liquid from accidentally passing over into the mouth (D) Hooked cannula (E) Blade to support the tongue and provide a patent airway (b) The Junker bottle used for insufflation employs a hand pump as the source of air

5 Liquid ether may be propelled into the pharynx if the vaporizer is not equipped with a trap
6 Objectionable quantities of ether are inhaled by members of the surgical team

Comment	*Reasons*
1 Always start and test vaporizer before placing the hook or catheter in the mouth or in the nose of the patient	Leaks or other mechanical defects may decrease the output of vapor even though the apparatus appears to function well High concentrations of ether, liquid ether, or gases under pressure may be blown into the upper respiratory tract if apparatus is defective
2 Judge depth of anesthesia by the responses of the patient to the ether and not by the size of the stream or the rate of vaporization of the liquid	Vaporization varies as the temperature of the ether changes
3 Lower head below the level of the shoulders in performing intraoral, intranasal, or intrapharyngeal operations or if secretions are excessive	Prevent aspiration of secretions or blood into trachea or bronchial tree
4 Remove hook from mouth or catheter from nose when ether is discontinued	If apparatus is equipped with a warming device, pure ether vapor may be distilled into pharynx and cause spasm or overdosage
5 If vaporization is inadequate surround the ether container with warm water to assist in vaporization	Ether becomes progressively cooler and does not vaporize so well as the operation proceeds
6 Add sufficient oxygen to whatever gas is employed to propel the vapor	The oxygen tension may be reduced to dangerously low levels unless extreme care is exercised

Variations of Insufflation Technique

1 *Insufflation into pharyngeal airway*

a The delivery tube from the vaporizer is attached to an oropharyngeal airway equipped with a nipple designed for the purpose, or a catheter may be threaded through its lumen into the pharynx Anesthesia then proceeds as in the foregoing techniques

2 *Insufflation into tracheotomy cannula*

a A loose fitting lubricated catheter attached to the insufflation tube may be inserted for a distance of one to two inches into the cannula The patient is first anesthetized by the open drop method by placing the mask on the neck over the cannula and then gentle insufflation is practiced at a positive pressure not to exceed 25 mm Hg

Ether Analgesia

Description Use of Stage I anesthesia obtained by inducing stage III anesthesia and permitting patient to pass back into lower strata of stage I

Uses

1 For surgery in which the patient's constitution forbids use of deep anesthesia (poor risk patients for cardiac surgery)

Preparation

1 Explain contemplated procedure to patient and assure that no pain or discomfort will ensue
2 Administer scopolamine, atropine or other anticholinergic agent one hour before induction time
3 Administer pentothal in divided doses to induce light basal narcosis Technique is best carried out in anesthesia room

Procedure

1 Anesthetize patient deeply with ether, using open drop, nitrous oxide or ethylene ether oxygen sequence
2 Intubate using succinyl choline and topical anesthesia
3 Discard ether mixture and allow patient to pass back into first stage
4 Add sufficient amount of ether to maintain patient in this Stage I

Comment

1 Maintain level at point at which patient barely responds to questioning
2 Remember nausea and vomiting may occur if analgesic state is too light
3 "Bucking" and gagging are prevented by use of topical anesthesia
4 Not suitable for states requiring muscle relaxation
5 Be sure to induce surgical anesthesia (Stage III) then permit reversal into stage I
6 Some patients not suitable for the technique—become unruly and uncooperative

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NITROUS OXIDE ANESTHESIA

Description A non irritating, sweet-smelling, non inflammable, inorganic gas which possesses a mild narcotic potency The anesthesia it produces is

characterized by a rapid induction and rapid recovery but is rarely deeper than first plane (Fig 34)

Uses

1 For operations not requiring profound anesthesia or muscle relaxation
2 As an induction agent for ether
3 As a supplemental agent to basal narcosis or intravenous anesthesia
4 For operations requiring use of cautery, endotherm, endoscopes, or other electrical equipment which may be a source of fire hazard
5 For analgesia for obstetrical or dental surgery
6 For thoracic surgery

Cost Relatively inexpensive, 1¢ to 1½¢ per gallon

Concentration

1 Analgesia, 35–50% by volume in the alveoli
2 Anesthesia, 80–90% by volume in the alveoli
3 Respiratory failure, 90–100% by volume in the alveoli (due to the combined effects of anoxia and the drug)

Premedication

1 Morphine and scopolamine or morphine and atropine in full therapeutic doses (see premedication) The doses employed should be large enough to decrease reflex irritability and metabolic rate

Materials

1 Machine having a flowmeter for nitrous oxide and oxygen, a closed inhaler equipped with an exhalation valve (circle filter), and a vaporizer
2 Sphygmomanometer
3 Artificial airway
4 Intercoupler (if the addition of ether is contemplated)

Procedure for Nitrous Oxide Oxygen Anesthesia	*Reasons*
1 Close the obturator at the mask and fill inhaler with nitrous oxide 85% and oxygen 15%	A full bag is employed at the outset to more quickly dilute and displace the air in the apparatus and lungs with anesthetic gas
2 Adjust but do not fasten mask to face	Stimulation created by the pressure may cause patient to become excited as he passes through stage II
3 Turn on carbon dioxide absorber and open obturator so that pa	Carbon dioxide should be removed to prevent the feeling of suffoca

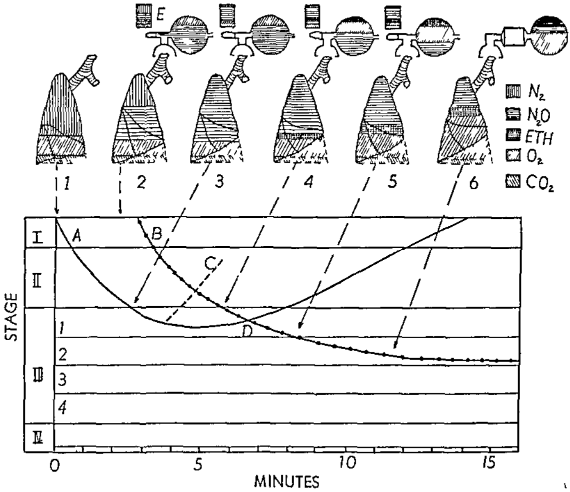

FIG 34 Changes in gas tensions in the lungs, inhaler, and expired gases during the induction and maintenance of nitrous oxide ether sequence anesthesia by the semi-closed technique The subject breathes from an inhaler into which is admitted a mixture of oxygen and nitrous oxide (1) The air in the lungs is mixed with the gas (2) The nitrogen normally present in the lungs is eliminated through the exhalation valve The patient passes into surgical anesthesia (Curve A) as soon as the nitrogen is replaced by nitrous oxide (85%) (3) When first plane anesthesia is attained addition of ether is started (Curve B) The ether concentration required for surgical anesthesia can be more rapidly attained during the easily induced anesthesia of the non irritating nitrous oxide The flow of nitrous oxide must be maintained while ether is being added otherwise recovery occurs (Curve C) before sufficient drug is present in the alveoli to maintain third stage ether anesthesia (4) The concentration of ether is sufficient for surgical anesthesia (5) The flow of nitrous oxide may be gradually diminished since enough ether is added to maintain first plane anesthesia (Point D) (6) Rebreathing with a closed inhaler is then instituted During induction some nitrous oxide and ether are also lost through the exhalation valve along with carbon dioxide and nitrogen (L) Some nitrous oxide remains in the inhaler and lungs during maintenance Although the lungs are depleted of nitrogen in the beginning of maintenance some is gradually eliminated from the tissues and accumulates in the inhaler (6) Ether must be added from time to time or even continuously in large subjects to replace the drug absorbed by the tissues Oxygen is added to satisfy metabolic needs carbon dioxide is absorbed by soda lime

tient breathes from the inhaler

4 Adjust flowmeter to deliver oxygen at 1200 cc and nitrous oxide at 4 liters per minute (or

tion which patients frequently experience during induction

A mixture of 80% nitrous oxide and 20% oxygen is thus assured in the inhaler (Table VI)

80% N_2O 20% O_2 if automatic, demand type mixing meter is employed)	
5 Open exhalation valve sufficiently to allow excess gases to escape from inhaler but not so wide that the bag becomes deflated	Nitrogen, some nitrous oxide, and carbon dioxide are eliminated during each exhalation Ultimately most of the nitrogen in the alveoli is replaced by nitrous oxide and oxygen and the patient passes into stage III
6 Increase or decrease the flow of nitrous oxide to the amount required to obtain and maintain anesthesia	The alveolar tension of the gas necessary for anesthesia varies according to the individual, the state of the patient, and effectiveness of premedication No fixed percentages can be recommended
7 As soon as the patient is in stage III fasten mask securely to face	A snug fit prevents inhalation of air about the face cushion and subsequent dilution of the mixture
8 Allow mixture to flow until patient is in stage III then decrease the flow of nitrous oxide to approximately 1000 cc per minute or less according to the needs of the patient Add O_2 according to Table VI	The mixture in the inhaler and lungs tends to become diluted from leaks, nitrogen, oxygen, etc , and patient will recover from anesthesia at an inopportune moment if nitrous oxide is not added in small amounts
9 Close exhalation valve almost entirely but allow for escape of excess gases which would accumulate in the apparatus	Overdistension of the breathing bag causes a positive pressure in inhaler which disturbs respiration

TABLE VI

PROPORTIONS OF NITROUS OXIDE AND OXYGEN WHICH MUST BE FLOWN INTO A SEMI-CLOSED INHALER TO ASSURE 20% OXYGEN IN THE MASK ON INSPIRATION

N_2O	O
400 cc	600 cc
500	625
750	675
1000	750
1500	800
2000	850
2500	925
3000	1000
3500	1100
4000	1200
4500	1400
5000	1550
5500	1700
6000	2000

Comment

1 An 80–20% O_2 mixture does not assure adequate oxygenation unless supplied at the minute volume exchange of the patient Enrich the mixture when using flows at less than this rate (Table VI)
2 Always turn soda lime absorber on Carbon dioxide accumulates unless mixture is supplied at minute volume exchange

Signs of Anesthesia

1 Without anoxia the signs of nitrous oxide anesthesia conform to those enumerated in the table Judging the Depths of Inhalation Anesthesia (p 88)

If anesthesia cannot be maintained in stage III without decreasing the oxygen to less than 20%, ether or other desired drug should be added to the mixture and oxygen tension increased as described below

Nitrous Oxide Ether Oxygen Sequence (Fig 34)	*Reasons*
1 Begin as for nitrous oxide oxygen anesthesia	Induction is same as for nitrous oxide oxygen
2 As soon as patient passes into stage III turn off carbon dioxide filter	Carbon dioxide is desirable to stimulate respiration and increase tidal exchange to facilitate absorption of ether
3 Start vaporizing ether gradually and increase concentration as rapidly as patient tolerates the vapor	Additions of ether must be gradual and in amounts which patient can tolerate Excess ether causes cough mucus secretion, or spasm of the larynx
4 Continue flow of nitrous oxide and oxygen allowing exhalation valve to remain open during the introduction of ether	Anesthesia with nitrous oxide must be maintained while ether is being raised to the concentration necessary for surgical anesthesia (Fig 34)
5 When the necessary concentration of ether is attained, gradually decrease flow of nitrous oxide Decrease at rate of 1000 cc every two minutes Ultimately the entire flow will be off (within 5 minutes as a rule)	All concentrations of gases and vapors should be raised or lowered gradually
6 Close exhalation valve when the flow of nitrous oxide is stopped and adjust oxygen to 400–500 cc per minute	This institutes rebreathing of ether and carbon dioxide because the filter is still off

7 Allow a hyperpnea to develop Continue to add ether as rapidly as tolerated during the hyperpnea	The absorption of ether in the alveoli is facilitated during the increased ventilation
8 As soon as the hyperpnea becomes maximal and respiratory excursions begin to decline from the depression caused by carbon dioxide, gradually turn on the filter Doing it in steps taking 3 or 4 minutes to go from off to on	Remove carbon dioxide to prevent deleterious effects on circulation and respiration Carbon dioxide in high concentrations causes depression of the central nervous system
9 If after carbon dioxide is removed, the patient does not tolerate the ether concentration present in the inhaler, dilute mixture with a few hundred cc of nitrous oxide Discontinue carbon dioxide absorption, reestablish a hyperpnea, and gradually increase the ether once more	Carbon dioxide possesses some anesthetic properties and its rapid removal causes lightening of anesthesia If the concentration of ether in the inhaler is too high, the patient may hold his breath or cough as soon as the carbon dioxide is removed
10 Gradually turn on the filter This time the ether concentration is usually tolerated If not, repeat the process once again or as often as necessary for the concentration to be tolerated	Carbon dioxide reestablishes the hyperpnea necessary to facilitate absorption of ether
11 Continue addition of ether and adjust oxygen to the patient's metabolic requirement (250–300 cc per minute)	Ether must be added throughout the operation to replace the portion absorbed by tissues from the blood

Signs of Anesthesia

1 The signs of anesthesia are identical with those described for ether

Advantages of Nitrous Oxide

1 It is non inflammable
2 It is non irritating to the respiratory tract
3 It is inexpensive if carbon dioxide absorption technique is employed
4 Induction and recovery are rapid (2–3 minutes)
5 It does not depress the respiratory or circulatory system
6 It disturbs physiological functions only slightly if oxygenation is adequate
7 Post anesthetic nausea and emesis are not common
8 It is useful for analgesia, either continued or intermittent

Disadvantages of Nitrous Oxide

1 It does not ordinarily yield anesthesia below first plane unless accompanied by some anoxia
2 Relaxation of muscles is inadequate for major surgery
3 Danger of asphyxia is always present, particularly when administered by inexperienced individuals

Complications	*Cause*
1 Failure to obtain third stage anesthesia	Usually due to unsatisfactory pre medication or dilution of the gas by oxygen, air, or nitrogen
2 Apnea—usually lasts 10 or 15 seconds	Follows the addition of oxygen during anoxia Due to the loss of carotid body stimulation by the anoxemia
3 Retching and vomiting during anesthesia	Usually follows dilution of the mixture with air or oxygen with subsequent lightening of the anesthesia Most common when anoxia has been present
4 Anoxia	Due to reduction of oxygen tension by excess nitrous oxide

Signs of Anoxia with Nitrous Oxide

1 Increased rate and depth of respiration, frequently irregular and jerky, often accompanied by phonation, "crowing," or groaning on inspiration or expiration
2 Slow, bounding pulse (approximately 60)
3 Elevated blood pressure
4 Increased pulse pressure
5 Cyanosis of skin, mucous membranes, nail beds, and conjunctival vessels *Blood in the operative wound appears dark*
6 Rigidity of the muscles of the body, followed by twitchings of small muscles, gradually merging into convulsive movements of large muscles as the anoxia increases
7 Sweating and coldness of the skin
8 Dilated pupils, which do not react to light
9 Secretion of small amounts of thick glairy mucus

Overdosage

1 *Signs*

a *Without anoxia* Overdosage is a remote possibility unless the subject is debilitated or moribund, or basal narcosis or large doses of nonvolatile drugs are employed in conjunction with the agent

b *With anoxia*

1. Respiratory failure Usually preceded by irregular, stertorous, spasmodic, or very rapid breathing
2. Marked cyanosis of mucous membranes and skin
3. Bradycardia
4. Hypertension—a rapid fall in blood pressure soon supervenes if not relieved
5. Widely dilated pupils
6. Spasticity of muscles (in early stages) followed by twitchings and convulsive movements Complete flaccidity soon appears
7. Loss of all reflexes

Treatment of asphyxia

a *Artificial respiration*

1. Insert an artificial airway (oropharyngeal)
2. Hold mask firmly on face and secure a snug fit
3. Fill rebreathing bag of the inhaler with pure oxygen
4. Inflate thorax by alternately compressing and relaxing breathing bag If spasm is present, force oxygen into lungs Even a small amount may assist in relieving the anoxia and overcoming the spasm

Contra-Indications	*Reasons*
1 Nitrous oxide without any reduction in the normal alveolar oxygen tension	
None, if depth of anesthesia obtained by this technique is satisfactory	
2 Nitrous oxide with a slight or moderate decrease in alveolar oxygen tension	
a Hypertension and associated cardiovascular diseases	Anoxia causes an elevation of blood pressure and increases cardiac irritability
b All types of diseases of the respiratory tract, but particularly if vital capacity is lowered	The decrease in oxygen tension, even though slight, may cause severe anoxemia in pulmonary disease
c Diabetes, renal insufficiency, or acidosis from any cause	Anoxia enhances acidosis regardless of its etiology
d Impaired liver function	Anoxia markedly disturbs liver function
e Fever, toxemia, or diseases accompanied by an increase in metabolic rate	The basal oxygen requirement is increased in these conditions A decrease in efficiency of the agent is observed

f Shock, *hemorrhage,* or anemias	Anoxia increases capillary permeability and enhances peripheral circulatory failure
3 Nitrous oxide with ether The contraindications are identical with those described for ether (see ether)	The addition of ether to nitrous oxide immediately converts the anesthesia to an ether anesthesia

Comment	*Reasons*
1 Do not expect the impossible of nitrous oxide	The gas is satisfactory for induction of ether anesthesia or first plane anesthesia but not for deeper anesthesia
2 Do not expect satisfactory anesthesia without proper premedication	Premedication facilitates nonasphyxial anesthesia with this drug
3 Do not tolerate leaks about the face piece or in other parts of the inhaler	Air aspirated into the apparatus reduces potency of the mixture by decreasing the partial pressure of nitrous oxide in the alveoli
4 Avoid introducing an artificial airway during nitrous oxide anesthesia unless it is absolutely necessary to do so	Anesthesia is so light that often the patient inhales room air during the insertion and recovers before the airway is properly placed
5 Observe nail beds, mucous membranes, and conjunctival vessels for cyanosis in Negroes or other heavily pigmented subjects	These structures lack the usual skin pigment and best reveal the presence of excess reduced hemoglobin
6 Record blood pressure and palpate pulse frequently during nitrous oxide anesthesia	Circulatory changes offer excellent criteria for detecting the presence of anoxia
7 Do not rely upon cyanosis as a symptom of anoxemia	Cyanosis may not be apparent in severe anemias The appearance of cyanosis depends upon (1) the hemoglobin content of blood, (2) amount of pigment in the skin, (3) caliber of the peripheral vessels, and (4) thickness of the skin
8 Rely upon physiological responses as guides to depth of anesthesia and degree of oxygenation rather than the proportions of gases registered by flowmeters	Discrepancies frequently exist between the flow of gases registered and concentrations delivered because these flowmeters are subject to mechanical derangements
9 Always employ the semi closed method for induction of anesthesia (Fig 34)	The nitrogen in the alveoli must be replaced by nitrous oxide to obtain anesthesia and can be elimi

	nated only by ejecting it through the exhalation valve
10 Revert to the closed system for the maintenance of anesthesia	The closed system affords a saving of gas and better control of carbon dioxide tension
11 Add oxygen cautiously during induction and maintenance	Sudden or excessive dilution of the mixture may cause the patient to pass from stage III to stage II

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Goodman L and Gilman A The Pharmacological Basis of Therapeutics Pp 81-86 The Macmillan Co New York 1941

ETHYLENE ANESTHESIA

Description A non irritating, inflammable, gaseous hydrocarbon which possesses an ethereal odor and a mild narcotic potency The anesthesia it produces is characterized by a rapid induction and recovery but is rarely deeper than first plane (Fig 34) *

Uses

1 For operations requiring approximately first plane anesthesia
2 As an induction agent for ether
3 For thoracic surgery, because of its non irritating qualities
4 As a supplemental agent for intravenous anesthesia or basal narcosis
5 For analgesia for obstetrical or dental surgery

Cost

1 Relatively inexpensive 1½¢ to 2¢ per gallon

Concentration

1 Analgesia 35% to 50% by volume in the alveoli
2 Anesthesia 80% to 85% by volume in the alveoli In well premedicated subjects, less than 80% may be effective
3 Respiratory failure 90% to 100% by volume in the alveoli (due to the combined effects of anoxia and the drug)

Premedication

1 Morphine and scopolamine or morphine and atropine in full therapeutic doses (see premedication) The doses employed should be large enough to decrease reflex irritability and metabolic rate

Materials

1 Machine having a closed inhaler equipped with an exhalation valve

* Ethylene has potency, pharmacological properties and uses similar to nitrous oxide

2 Sphygmomanometer
3 Artificial airway
4 Intercoupler (at all times)

Procedure for Ethylene Oxygen Anesthesia	*Reasons*
1 Fill breathing bag (5 liter) with an 80%-20% mixture Close obturator at mask	A bag filled with the gas is employed at the outset to more quickly dilute and displace the air in the appartus and lungs with anesthetic gas
2 Adjust, but do not fasten mask to face	If the mask is fastened, the stimulation may cause excitement in passing through stage II
3 Turn on carbon dioxide filter and open obturator so that patient breathes from the inhaler	Carbon dioxide should be removed to prevent the feeling of suffocation which patients frequently experience during induction
4 Adjust flowmeter to deliver 1200 cc of oxygen and 4 liters of ethylene per minute	A mixture of approximately 80% anesthetic gas and 20% oxygen is thus assured in the inhaler
5 Open exhalation valve to allow excess gas to escape but not so wide that bag becomes deflated	Nitrogen and some ethylene are thus eliminated with each expiration Ultimately the nitrogen in the alveoli is replaced by ethylene and oxygen and the patient passes into stage III
6 Increase or decrease the flow of ethylene to the amount required	The alveolar tension of the gas necessary for anesthesia varies ac

TABLE VII

PROPORTIONS OF ETHYLENE AND OXYGEN WHICH MUST BE FLOWN INTO A SEMI-CLOSED INHALER TO ASSURE 20% OXYGEN IN THE MASK ON INSPIRATION

Ethylene	*Oxygen*
400 cc	600 cc
500	625
750	675
1000	750
1500	800
2000	850
2500	925
3000	1000
3500	1100
4000	1200
4500	1400
5000	1550
5500	1700
6000	2000

to obtain and maintain anesthesia	cording to the individual patient and effectiveness of premedication No fixed percentages can be recommended
7 As soon as patient is in stage III, fasten mask securely to the face	A snug fit prevents inhalation of air around face cushion and subsequent dilution of the mixture
8 Reduce flow of ethylene to 1000 cc or less per minute according to needs of patient Add oxygen according to Table VII	Small amounts of ethylene must be added continuously because mixture in inhaler tends to become diluted by nitrogen and oxygen from leaks and other causes
9 Close exhalation valve almost completely but allow for escape of excess gases	Overdistension of the breathing bag causes positive pressure in the inhaler which disturbs respiration

Signs of Anesthesia If anoxia is not present, signs of anesthesia with ethylene conform to those enumerated in the table under Judging Depths of Anesthesia (page 88) If anoxia complicates the anesthesia, the signs are altered and not at all reliable

Comment

1 If anesthesia cannot be maintained in stage III without reducing the oxygen tension to less than 20% ether should be added to the mixture and the oxygen tension increased as described below

2 An 80 20% O_2 mixture does not assure adequate oxygenation unless supplied at the minute volume exchange of the patient Enrich the mixture when using flows at less than this rate (Table VII)

3 Always turn soda lime absorber on Carbon dioxide accumulates unless the mixture is supplied at the minute volume exchange

Procedure for Ethylene Ether Oxygen Sequence (Fig 34)	*Reasons*
1 Begin as for ethylene anesthesia	Induction is same as for ethylene-oxygen
2 As soon as stage III has been attained with the ethylene oxygen mixture, turn off carbon dioxide filter	Carbon dioxide produces a hyperpnea and also a certain amount of depression, both of which hasten induction
3 Start vaporizing ether slowly at first and increase the concentration as fast as patient tolerates it	If ether concentration is raised too quickly, cough, and laryngeal spasm may result
4 Continue to flow ethylene oxygen Allow the exhalation valve to remain open during introduction of ether	Anesthesia from ethylene must be maintained while the concentration of ether is being raised to the level necessary for surgical anesthesia

5 Gradually decrease flow of ethylene in steps of 1000 cc per 1–2 minute intervals as the ether tension necessary to maintain third stage anesthesia is attained Ultimately shut off entire flow (usually within five minutes)	All concentrations of gases and vapors should be raised or lowered gradually
6 Close exhalation valve as soon as flow of ethylene is stopped and allow hyperpnea to develop Add ether as rapidly as tolerated during the hyperpnea	The hyperpnea increases tidal exchange and hastens absorption of ether
7 As soon as hyperpnea is maximal and respiratory excursions begin to decline from the depressant action of carbon dioxide, gradually turn on soda lime filter taking 2–3 minutes to go from "off" to "on"	Carbon dioxide exerts deleterious effects on circulation and respiration if not removed when signs of depression appear
8 If, after carbon dioxide is removed, patient does not tolerate ether concentration present in inhaler, dilute mixture with several hundred cc of ethylene Discontinue ether and carbon dioxide absorption and reestablish a hyperpnea Resume ether, and gradually turn on filter as in the previous step	Removal of carbon dioxide causes lightening of anesthesia because carbon dioxide possesses anesthetic properties Carbon dioxide should be removed gradually during induction
9 Continue the addition of ether and adjust the flow of oxygen to the patient's metabolic requirement	Tissues constantly absorb ether from the blood which must be replaced

Signs of Anesthesia

1 The signs of anesthesia are identical to those described under Judging Depths of Anesthesia (page 88)

Advantages of Ethylene

1 Induction and recovery periods are rapid (2–3 minutes)
2 It is nonirritating to the respiratory tract
3 It disturbs physiological functions only slightly if adequate oxygenation is maintained
4 It is more potent than nitrous oxide when employed in similar circumstances

5 It does not notably disturb respiratory or circulatory systems
6 It is inexpensive if the carbon dioxide absorption technique is employed

Disadvantages

1 It does not ordinarily yield anesthesia below first plane unless anesthesia is accompanied by some anoxia
2 Its odor is unpleasant to some patients
3 Post anesthetic nausea and emesis are not uncommon
4 Relaxation of muscles is not adequate unless followed by ether or employed in conjunction with some other agent
5 Its range of inflammability varies from 1 5% to 80% with oxygen at the usual room temperatures and atmospheric pressures
6 Danger of asphyxia is always present if the concentration is increased

Complications

1 Failure to obtain third stage Supplement with ether and oxygen Ineffective premedication or the mixture contains too much oxygen
2 Vomiting during maintenance of anesthesia Due to lightening of anesthesia from dilution of mixture with air or oxygen
3 Coughing Due to reducing the flow of ethylene too soon during ether induction
4 Anoxia Symptoms, similar to those observed when it occurs with nitrous oxide Due to reduction of oxygen tension by ethylene

Signs of Anoxia with Ethylene

1 The signs of anoxia are identical in most respects to those described under nitrous oxide (page 112)

Overdosage

1 Signs of overdosage are identical to those described under nitrous oxide (page 112)

Contra Indications	*Reasons*
1 *Without anoxia* None, save operations requiring cautery and high frequency units	The gas is highly inflammable when mixed with either air or oxygen
2 *With a mild degree of anoxia* (the usual method)	
(a) Hypertension and associated cardiovascular diseases	Effects of anoxia on circulatory system are deleterious
(b) Acute or chronic pulmonary diseases, particularly if vital capacity is lowered	Decreased oxygenation even of slight degree may be deleterious

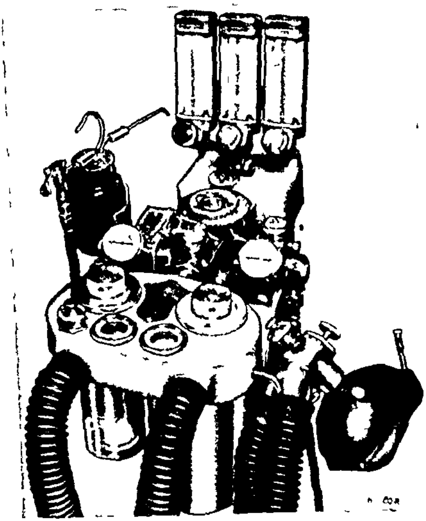
(c) Diabetes, renal insufficiency, or acidosis from any cause	Anoxia enhances acidosis regardless of its etiology
(d) Diseases accompanied by decreased liver function	Anoxia disturbs liver function
(e) Fever, toxemia, or diseases accompanied by increased metabolic rate	The basal oxygen requirement is increased
(f) Shock, hemorrhage, or anemias	Anoxia increases capillary permeability and enhances peripheral circulatory failure
3 *Ethylene-Ether* The contraindications are identical to those described for ether	The addition of ether immediately converts an ethylene anesthesia to an ether one

Comment	*Reasons*
1 Do not expect the impossible from this agent	The drug is a satisfactory induction agent for ether and first plane anesthesia, but not for deeper anesthesia
2 Do not tolerate leaks about the face piece	The patient aspirates air which dilutes the ethylene and reduces its potency
3 Refrain from employing an artificial airway if possible	If it is necessary, insert it as quickly as possible to avoid ascent into stage II and return of pharyngeal reflex
4 Add oxygen cautiously during induction or maintenance of anesthesia	Sudden or excessive dilution of ethylene by oxygen may cause patient to revert into stage II from stage III
5 Always employ the semi closed method for induction	Nitrogen in the alveoli must be replaced by ethylene to obtain anesthesia This is best accomplished by eliminating it through the exhalation valve
6 Revert to the closed system during maintenance of anesthesia (the semi closed system if desired, may be employed throughout)	The closed system affords a saving of gas and a decrease in fire hazard

Nitrous Oxide Using Demand Type Apparatus (McKesson)

The McKesson apparatus (Nargraff head) is a semi closed inhaler Several models are available with the following features

1 Automatic mixing device (Nargraff Head) which supplies preformed mixtures of nitrous oxide and oxygen



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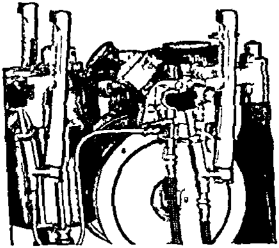

B

FIG 35 The McKesson anesthetic apparatus A Recent model with Nargraff (automatic mixing demand supply) unit and flow meters for nitrous oxide cyclopropane and oxygen B Older model embodying same features with old style flow meter and without flow meter for nitrous oxide

2 An automatic feeding device activated by reduced pressure in the inhaler caused by escape of gas or inspiratory negative pressure Replaces gas lost from inhaler
3 Device for adjusting pressure in the inhaler Pressure ranges from atmospheric to 40 mm Hg in the system
4 A bellows type breathing bag adjustable to permit partial to complete rebreathing Notches on side limit excursions of bellows Each notch =100 cc (This is present on dental models)
5 Key for adjusting pressure in bellows Each figure on side indicates one mm Hg 10=10 mm Hg (on dental models)
6 Indicator dial on top for
   (a) rebreathing volume (red pointer)
   (b) tidal volume (black pointer)
      (also on dental models)
7 Variable reducing valves at each yoke which permits pressure in mixing device to be constant as cylinder becomes exhausted (All models)
8 Gauges for indicating pressure of oxygen and nitrous oxide supplied to mixing meter (All models)
9 Exhalation valve (adjustable) (All models)
10 Valve to shut off ethylene and admit nitrous oxide and vice versa
11 Vaporizer for volatile liquids—type varies with agent used
12 Emergency direct flow oxygen button (All models)

The combined semi closed and closed apparatus (Fig 35) has the following features minus the bellows for rebreathing

13 Soda lime canister for absorption of carbon dioxide
14 Breathing bag
15 Shut off valve device for excluding bag from system
16 Auxilliary bag for retaining gases and maintaining anesthesia when soda lime is changed
17 Oxygen flowmeter
18 Cyclopropane flowmeter
19 Carbon dioxide flowmeter

Technique Using Semi Closed Apparatus and Bellows

Technique

1 Set pressure gauge on off (3, Fig 36)
2 Close ethylene (5, Fig 36) and open nitrous admit valve (6, Fig 36) on Nargraff head
3 Open main cylinder valves for oxygen and nitrous oxide entirely
4 Turn screws controlling reducing valves downward until pressure gauges (4 and 7, Fig 36) on Nargraff head registers 40–60 lbs for both oxygen and nitrous oxide

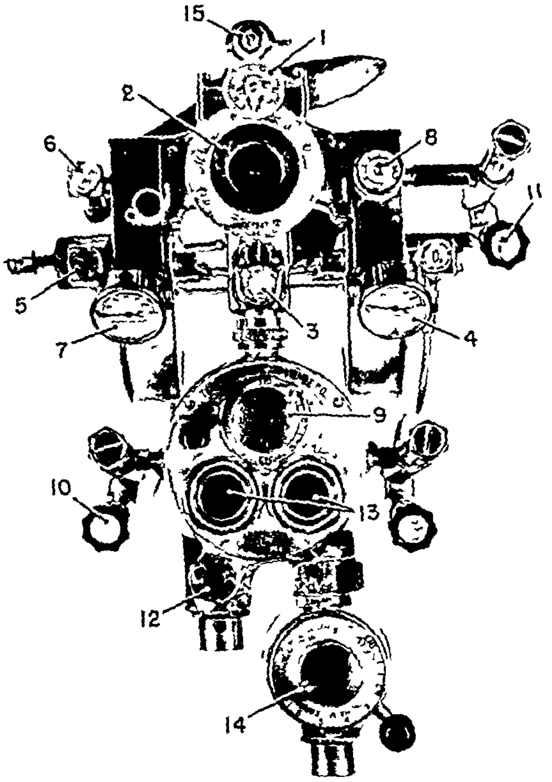

Fig. 36 Top view of McKesson anesthetic apparatus showing the various parts described in the text (1) Vernier oxygen control valve on automatic mixer (2) Coarse adjustment oxygen control valve on automatic mixer (3) Positive pressure control gauge (4) Oxygen pressure gauge to automatic mixer (5) Nitrous oxide valve to automatic mixer (6) Ethylene valve to automatic mixer (7) Nitrous oxide pressure gauge to automatic mixer (8) Energizing oxygen flush valve (9) Carbon dioxide absorber control (10) Cyclopropane flow meter (11) Oxygen flow meter (12) Exhalation valve (13) Flutter valves on soda lime canister (14) Ether vaporizer

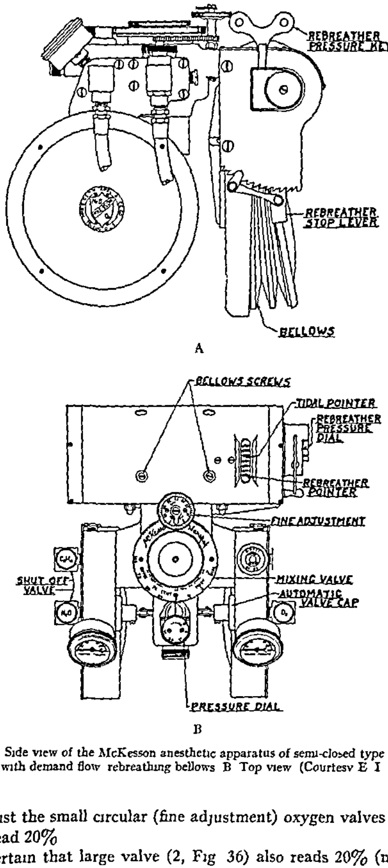

FIG 37 A Side view of the McKesson anesthetic apparatus of semi-closed type with automatic mixing device with demand flow rebreathing bellows B Top view (Courtesy E I McKesson Toledo Ohio)

5 Adjust the small circular (fine adjustment) oxygen valves (1, Fig 36) to read 20%
6 Ascertain that large valve (2, Fig 36) also reads 20% (not 80%)
7 Open exhalation valve (12, Fig 36) partly to allow gas to escape

8 Turn pressure control valve (3, Fig 36) to 5 mm Hg and allow some gas to escape to flush out apparatus
9 Adjust bellows (Fig 37) to 200 cc rebreathing by putting bellows stop into 2nd notch
10 Set rebreathing pressure key to equal pressure at pressure dial (Fig 37)
11 Open pressure valve to register between 0–5 mm Hg until gas flows
12 Adjust mask to face
13 Open exhalation valve to allow excess gas to escape and permit patient to breathe mixture until anesthetized
14 Adjust pressure gauge valve to provide adequate flow and excursions of the bellows

Comment

1 Rebreathing is not desirable because it is not physiological
2 Vinyl ether, ethyl ether, trichlorethylene or chloroform may be added to fortify mixture Increase oxygen to 25%

Technique Using Nargraff, Bag and Soda Lime Absorber

1 Set pressure gauge on off (1, Fig 36)
2 Close ethylene (5, Fig 36) and open nitrous admit valve (6, Fig 36) on Nargraff head
3 Open main cylinder valves for oxygen and nitrous oxide entirely
4 Turn screws controlling reducing valves downward until pressure gauges on Nargraff head registers 40–60 lbs for both oxygen and nitrous oxide
5 Close obturator of Y mask holder
6 Turn pressure gauge (3, Fig 36) to read five or more mm Hg to allow bag to fill with mixture
7 Close to zero as soon as bag is full
8 Turn soda lime absorber to "on position"
9 Adjust mask to face and open obturator
10 Open exhalation valve sufficiently to allow excess gas to escape
11 Turn pressure valve between 1 and 5 until gas flows and permit patient to breathe mixture until anesthetized

Nitrous Oxide Ether Oxygen Sequence Using Bag and Filter

12 Allow patient to pass into Stage III using above procedure
13 Turn on ether (14, Fig 36) without disturbing nitrous oxide mixer setting or the pressure setting
14 Advance ether gradually but as rapidly as patient tolerates
15 After 3–5 minutes gradually decrease pressure setting by turning valve slightly and close exhalation valve partially with each decrease so that

automatic gas flow is reduced but is sufficient to keep bag full Take 3 or 4 minutes to reduce flow until nitrous oxide oxygen is off completely

16 Set oxygen (metabolic) at 300 cc per minute
17 Turn absorber to off position and allow hyperpnea to develop
18 Increase ether gradually as hyperpnea develops
19 Allow hyperpnea to develop until maximal and depression of respiration appears
20 Turn ether control back half way
21 Gradually, over a period of several minutes, turn on soda lime absorber until it is in "on" position
22 Advance ether gradually to point which maintains desired depth of anesthesia

Comment

1 Manipulations and reasons are basically same as those described for nitrous oxide-ether sequence for standard flow meter technique
2 Positive pressure of 15 mm Hg theoretically increases efficiency of nitrous oxide but in actual practice is of little value

Nitrous Oxide Oxygen Demand Principle for (McKesson) Dental Surgery

Materials McKesson semi closed apparatus with rebreather and oronasal mask to be followed by nasal attachment

Preparation

1 Patient should be fasting and be premedicated

Procedure

1 Sit in dental chair
2 Restrain legs and wrists
3 Loosen collar
4 Apply mask and commence flow of nitrous oxide as described above for semi-closed apparatus with rebreather until 3rd stage is attained
5 Set exhale valve at 5 mm Hg
6 Set pressure valve at 5 mm Hg
7 Quickly remove mask and substitute nasal piece and fit over nose
8 Increase nitrous oxide to 90% and decrease oxygen to 10%
9 Adjust pressure in apparatus to permit adequate flow
10 Set rebreather at pressure of 12 and rebreath at 300
11 Pack mouth

Comment

Without premedication using this technique third stage cannot be obtained without anoxia Reinforce with

(a) Vinyl ether
(b) Trichlorethylene
(c) Basal narcotic such as pentothal

Ethylene Oxygen Using Demand (McKesson) Principle

1 Follow procedure outlined for nitrous oxide oxygen by same method (page 107) with following exceptions
   (a) Close nitrous oxide inlet valve (3, Fig 36) and open ethylene valve (2, Fig 36)
   (b) Maintain pressure for mixing at 60 lbs for ethylene and 60 lbs for oxygen
   (c) Follow same precautions outlined for ethylene by standard technique
2 Follow procedure outlined for nitrous oxide oxygen ether by same method (see nitrous oxide page 110)

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Nitrous Oxide or Ethylene Using the To and Fro Unit

The above mentioned procedures apply to the use of nitrous oxide or ethylene if the circle filter is employed When the to and fro inhaler is employed, the principles are the same, but manipulations vary in some respects Manipulations also vary with the type of to and fro inhaler employed The to and fro inhaler may be composed in one of the following ways

1 A mask, bag, and canister with no obturator or exhalation valve The ether vaporizer possesses no by pass so that all the gases from the flowmeter pass through or over the ether (Fig 7) The technique is as follows
   a Adjust the nitrous oxide or ethylene flow to 6 liters and the oxygen to 1500 cc per minute
   b Adjust the mask to the face and fasten securely If necessary, increase the flow of gases or add oxygen from the emergency valve so that the patient does not breathe from a collapsed bag at the outset
   c Allow the bag to fill with the mixture
   d After the bag is filled, allow the patient to rebreath from the inhaler for thirty to sixty seconds Then quickly tilt mask backward and

manually express all the mixture from the breathing bag This eliminates the nitrogen which has diffused from the lungs together with the ethylene and oxygen

e Fill the bag with fresh nitrous oxide-oxygen mixture and repeat the maneuver once or twice more or until the patient is in stage III

f Retard the flow of nitrous oxide and adjust oxygen at metabolic flow (see Table VI)

g Insert the canister into the inhaler To accomplish this as quickly as possible without loss of the mixture, the following routine should be followed

(a) Place the canister along the side of the patient's head so that mask end rests squarely against the right shoulder

(b) Grasp the breathing bag tightly about the neck in such a manner that there is no loss of mixture and slide it in to the sleeve of the bag end of the canister

(c) Pick up both the bag and canister and connect it to the mask, still maintaining the grasp about the neck

(d) Balance the canister as described on page 79 The operation should be completed in several seconds

h Replenish the mixture which may have been lost from the inhaler with nitrous oxide or ethylene

i From time to time at intervals of several minutes, add several hundred cc of nitrous oxide or ethylene and allow excess gases to escape by slightly tilting the mask

For nitrous oxide oxygen ether (or ethylene oxygen ether sequence), proceed as follows

(a) Begin addition of ether when stage III has been attained with the gas and gradually increase rate of vaporization by increasing oxygen flow

(b) As soon as the patient is in stage III, turn off nitrous oxide or ethylene completely and adjust oxygen to the metabolic flow (250–300 cc per minute)

(c) Allow the patient to rebreathe the mixture without the canister until the hyperpnoea reaches its maximum

(d) Introduce the canister in place Immediately afterward, dilute the mixture in the inhaler with several hundred cc of nitrous oxide or ethylene to avoid the lightening of anesthesia which results from removal of carbon dioxide

(e) Continue to add ether and carry anesthesia to the desired depth

2 A mask, bag, and canister with no obturator or exhalation valve, but a dropper type vaporizer on the inhaler (Fig 17) The gases do not pass through the liquid

The same technique as above is followed except that ether is added by controlling the dropper

3 A mask, bag, and canister with an obturator and exhalation valve The vaporizer is of the bubble type and possesses no by pass so that all the gases from flow meter pass through the liquid (Fig 18)

The technique is same as in 1 except that nitrogen is eliminated through the exhalation valve which is allowed to remain partially open rather than by tilting the mask.

4 A mask, bag, and canister, with an obturator, exhalation valve, and dropper vaporizer (Fig 22)

The technique is similar to that described for the circle filter except that the canister is not introduced into the inhaler until the hyperpnoea is maximal

Analgesia with Nitrous Oxide or Ethylene for Obstetrical Use

1 Close obturator, set the soda lime filter for absorption
2 Fill inhaler with 80% nitrous oxide or ethylene and 20% oxygen and have it in readiness
3 Ask patient to raise her hand at the first suggestion of a uterine contraction
4 Apply the mask to the face, open obturator, and ask the patient to breathe deeply during the contraction
5 Turn on the flow of gas mixture to keep inhaler filled
6 At the height of the contraction, ask her to hold her breath and "bear down"
7 Remove the mask when contraction is over, fill the inhaler, and have it in readiness for the next contraction

Comment	*Reasons*
1 Begin inhalation as soon as first sign of pain appears	A latent phase of 10 or 15 seconds elapses before the onset of analgesia Analgesia will be of no avail if inhalation begins at the height of the contraction
2 Use a high concentration of gas at the outset	The possibility of oxygen want is remote because the gas is diluted with the air in the alveoli
3 If administration is sustained over a period of several minutes, add oxygen to satisfy the metabolic rate	The possibility of anoxemia increases if the period of inhalation of mixtures of low oxygen tension is prolonged

Analgesia for Other Purposes

1 Follow the procedure for nitrous oxide anesthesia, but employ a concen

tration of 50% oxygen and 50% nitrous oxide at the outset

2 Increase or decrease the flow of nitrous oxide according to the requirement of the patient and maintain the stage of analgesia between the zone of pain relief and the zone of loss of consciousness

Nitrous Oxide or Ethylene with Other Volatile Agents Both gases may be employed with volatile drugs such as chloroform, trichlorethylene or vinyl ether Proceed in the same manner as for nitrous oxide ether or ethylene-ether

1 Place the liquid in the vaporizer
2 Fill the inhaler with a mixture of 3 liters of the gas to one of oxygen
3 Open the exhalation valve and allow the gas to pass into the inhaler in the same manner as for the gas ether sequence technique
4 Begin the vaporization and continue the administration by the semi closed technique Add O according to Table VI

Nitrous Oxide or Ethylene with Non volatile Agents

1 Nitrous Oxide Pentothal The gas provides analgesia, the pentothal unconsciousness and moderate relaxation Less pentothal and a lower concentration of gas are required than if each were used alone
   (a) Induce narcosis as described under pentothal (Part IV)
   (b) Follow procedure above using nitrous oxide or ethylene in proportions outlined in table VI or VII
   (c) Increase flow of gas according to requirement of patient, but in no case exceeding 80%-20% O
   (d) Add pentothal as needed
2 Nitrous Oxide or Ethylene-Avertin
   (a) Establish basal narcosis with avertin (Part V)
   (b) Proceed with nitrous oxide or ethylene using a 75%-25% O_2 mixture at outset
   (c) Decrease or increase gas concentration according to the needs of the patient, but in no case exceeding an 80-20% O_2 mixture
3 Nitrous Oxide or Ethylene Curare The gases provide the analgesia and anesthesia the curare the muscle relaxation
   (a) Administer adequate premedication
   (b) Induce anesthesia with the gas in the routine manner
   (c) Administer curare in 20 unit fractions intravenously, pausing 3 or 4 minutes between fractions until desired degree of muscle relaxation is secured
   (d) Intubate (if necessary) to maintain a free airway
4 Nitrous oxide pentothal-muscle relaxant
   (a) Premedicate patient in usual manner with a narcotic and scopolamine or atropine
   (b) Induce pentothal basal narcosis as described in Part IV

(c) Commence flow of nitrous oxide or ethylene oxygen using semi-closed technique with flows according to table V or VI
(d) Add muscle relaxant as described in Part IV Curare 60 units or equivalent of other muscle relaxant is administered intravenously

5 Nitrous Oxide or Ethylene-Regional The relaxation and analgesia are secured by the regional block, the gases are merely used for securing unconsciousness in uncooperative patients
(a) Proceed in the routine manner described above

CYCLOPROPANE

Description A stable, inflammable, and pleasant smelling gaseous hydrocarbon which is easily inhaled and quickly produces unconsciousness and surgical anesthesia

Uses

1 For anesthesia for all types of surgery Depth may be varied from 1st to 4th plane of stage III with adequate oxygenation
2 For rapid induction of anesthesia or a preliminary agent to ether Shortens stages I and II
3 As a supplemental agent to regional, rectal, intravenous, or other forms of anesthesia
4 For thoracic surgery (because of its potency and non irritating properties)

Cost Expensive, 35–40 cents per gallon

Method of Administration Cyclopropane can be satisfactorily administered only in a closed inhaler The cost and inflammable nature of the drug prohibit the use of any but the rebreathing techniques

Concentration

1 Analgesia approximately 8% by volume in the alveoli
2 Anesthesia 20–25% by volume in the alveoli
3 Respiratory failure 35–39% by volume in the alveoli

Premedication

1 Morphine and scopolamine or morphine and atropine ½ to ¾ of the usual therapeutic doses employed for ether
2 Basal narcosis using *pentothal, seconal or nembutal intravenously* (Part IV)

Materials

1 Machine with closed inhaler and flowmeter calibrated for cyclopropane Either the circle filter or the to and fro may be employed The technique is similar in both instances

tration of 50% oxygen and 50% nitrous oxide at the outset

2 Increase or decrease the flow of nitrous oxide according to the requirement of the patient and maintain the stage of analgesia between the zone of pain relief and the zone of loss of consciousness

Nitrous Oxide or Ethylene with Other Volatile Agents Both gases may be employed with volatile drugs such as chloroform, trichlorethylene or vinyl ether Proceed in the same manner as for nitrous oxide ether or ethylene ether

1 Place the liquid in the vaporizer
2 Fill the inhaler with a mixture of 3 liters of the gas to one of oxygen
3 Open the exhalation valve and allow the gas to pass into the inhaler in the same manner as for the gas ether sequence technique
4 Begin the vaporization and continue the administration by the semi closed technique Add O_2 according to Table VI

Nitrous Oxide or Ethylene with Non volatile Agents

1 Nitrous Oxide Pentothal The gas provides analgesia, the pentothal unconsciousness and moderate relaxation Less pentothal and a lower concentration of gas are required than if each were used alone
   (a) Induce narcosis as described under pentothal (Part IV)
   (b) Follow procedure above using nitrous oxide or ethylene in proportions outlined in table VI or VII
   (c) Increase flow of gas according to requirement of patient, but in no case exceeding 80%–20% O_2
   (d) Add pentothal as needed
2 Nitrous Oxide or Ethylene-Avertin
   (a) Establish basal narcosis with avertin (Part V)
   (b) Proceed with nitrous oxide or ethylene using a 75%–25% O_2 mixture at outset
   (c) Decrease or increase gas concentration according to the needs of the patient, but in no case exceeding an 80–20% O_2 mixture
3 Nitrous Oxide or Ethylene-Curare The gases provide the analgesia and anesthesia the curare the muscle relaxation
   (a) Administer adequate premedication
   (b) Induce anesthesia with the gas in the routine manner
   (c) Administer curare in 20 unit fractions intravenously, pausing 3 or 4 minutes between fractions until desired degree of muscle relaxation is secured
   (d) Intubate (if necessary) to maintain a free airway
4 Nitrous oxide pentothal muscle relaxant
   (a) Premedicate patient in usual manner with a narcotic and scopolamine or atropine
   (b) Induce pentothal basal narcosis as described in Part IV

4 Adjust and hold mask lightly to face	Avoid loss of gas into the room without causing discomfort by pressure
5 Partially fill system with 400 or 500 cc of oxygen, fasten mask and turn on obturator	Patient should not breathe from an empty bag or inhaler
6 Adjust flow of oxygen to 1000 cc. and cyclopropane to 600 cc per minute	A concentration of 37% by volume is delivered to the inhaler However, this becomes diluted by the air in the inhaler and lungs to approximately the anesthetic concentration
7 As soon as patient is in stage III or if bag fills before he is in stage III, discontinue flow of cyclopropane Then reduce the oxygen to metabolic rate (300 cc per minute) Observe signs of anesthesia closely	The anesthesia becomes deeper for a number of seconds following the termination of flow of gas due to a delay in establishing equilibrium between the alveolar and blood gases
8 If the bag fills before patient is in stage III, resume flow of cyclopropane after 30 seconds to 400 cc Maintain oxygen at the metabolic flow Observe patient closely	Cyclopropane concentration is being very rapidly increased when it flows into the inhaler at this rate
9 Add cyclopropane as necessary at the rate of 400–600 cc per minute for ½ to 1 minute at a time as required to maintain the desired depth Be guided by the signs and symptoms of narcosis shown by the patient	Tissues absorb drug from blood and thus cause the anesthesia to lighten The drug absorbed by the tissues must be replaced
10 Deepen the anesthesia prior to making the incision and before peritoneum is sutured or cut or other painful stimulation occurs	Painful stimuli tend to lighten the anesthesia

Cyclopropane—Alternate Method

Procedure

1 Empty breathing bag completely and close obturator
2 Turn on oxygen to 1000 cc and cyclopropane to 600 cc
3 Allow bag to fill completely with this mixture
4 Turn on soda lime absorber
5 Adjust metabolic flow of oxygen to 300 cc per minute and cyclopropane to 400 cc per minute
6 Apply mask to patient's face and allow him to begin to breathe the mixture

2 Artificial airway
3 Intercoupler
4 Sphygmomanometer

Procedure (see Fig 38)	*Reasons*
1 Arrange the patient and equipment in the routine manner described for ether or other gases	Preparations differ in no way from those required for other gas anesthetics

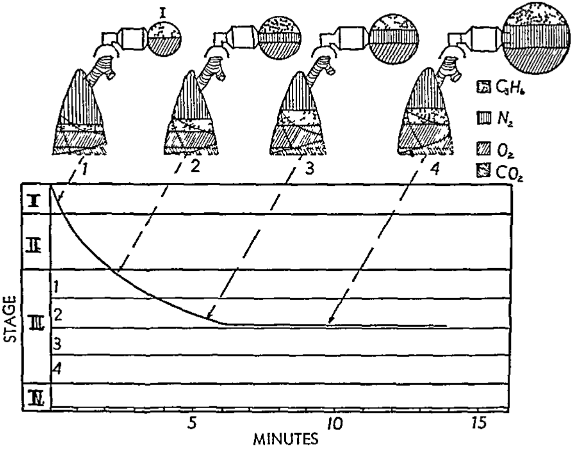

FIG 38 Induction and maintenance of anesthesia by the closed technique using cyclopropane This can only be accomplished when potent anesthetic agents which produce surgical anesthesia at low partial pressures are employed. Nitrogen need not be eliminated During the induction (1) a high concentration (40%±) of cyclopropane and oxygen is admitted into an almost empty inhaler As the inhaler fills the gases mix with the air of the lungs and dilution occurs The inhaler then contains nitrogen oxygen and cyclopropane (2) and (3) When surgical anesthesia is fully established the inhaler is full and an equilibrium exists between the gases in the alveoli and those in the inhaler (4) The concentration of cyclopropane if an inhaler of approximately 5 liters capacity is employed averages 25% by volume

2 Turn on carbon dioxide absorber if the circle filter is employed or insert the canister into the system if the to and fro is used	The hyperpnea of carbon dioxide is not necessary to accelerate induction Carbon dioxide may cause an elevation of blood pressure
3 Close the exhalation valve	Nitrogen need not be eliminated because the concentration required for anesthesia is low

	dilated Thorax is easily inflated Pulse is slow Tissues relaxed Reflexes are absent
2 *Apnea* Caused when high oxygen is employed in conjunction with morphine Also caused by inherent properties of the drug on the respiratory center	Patient may be light, but respiratory depression prevents adequate absorption of drug and attainment of satisfactory anesthesia Change to ether or use *controlled* respiration
3 *Cardiac arrhythmias* Many types may be observed extra systoles, coupled beats, auricular fibrillation, ventricular tachycardia, etc Due to increase in irritability of automatic tissue of the heart	Lighten anesthesia by adding oxygen If persistent, change to ether or other agent
4 *Unsatisfactory relaxation* (especially of abdominal muscles)	Change to ether or other anesthetic agent May be due to respiratory depression which prevents absorption of agent, to inherent property of drug, or to a resistant subject
5 *Laryngospasm*	Possibly due to parasympathetic stimulation or reflex stimulation of other types Apply pressure to bag to inflate chest Spasm may disappear with deepening of anesthesia Intubate, if spasm persists

Contra Indications to Cyclopropane

1 Cardiac disease of all types
2 Operations requiring use of cautery, high frequency units, or other equipment which may cause sparks or produce flames
3 Surgery performed by an operator who requires extreme relaxation

Advantages

1 It is rapid acting (3–5 minutes), pleasant, and non irritating in anesthetic concentrations
2 The anesthesia may be quickly lightened or deepened during the maintenance phase
3 Recovery is rapid, most of the drug is eliminated in ten minutes
4 The concentration required for anesthesia allows use of high partial pressures of oxygen (up to 60%–70% by volume)
5 Elimination of nitrogen is unnecessary so that the closed system may be used from the outset
6 It possesses a wide margin of safety
7 It is non irritating to the respiratory tract

7 As soon as patient is in third stage turn off cyclopropane and wait several minutes before adding more
8 Continue to add cyclopropane at 400 cc per minute at required intervals

Comment	*Reason*
1 Beware of the concentration	This concentration may be excessive for a non resistant patient

Cyclopropane—Oxygen Using McKesson

Procedure

1 Shut off all valves on automatic mixer and turn on cyclopropane and oxygen
2 Turn soda lime absorber to "on"
3 Close obturator
4 Flush in oxygen, approximately 700 cc
5 Turn cyclo flowmeter to 600 and oxygen to 1000 cc per minute
6 Apply mask and adjust
7 Open obturator

Comment

All other preparations and details same as for cyclopropane administered by other apparatus

Signs of Anesthesia Signs of anesthesia differ in certain respects from those characteristic of ether described in the table under Judging Depths of Anesthesia The following deviations are common

1 *Nervous System* Oculomotor activity is present until the third plane of stage III Pupils remain constricted and do not react to light Dilation is uncommon unless anoxia is present Lachrymation is common No sharp line of demarcation exists between planes 1 and 2

2 *Respiratory System* Amplitude and rate of thoracic movements are slightly decreased in first and second planes As third plane is attained, the amplitude and rate markedly and progressively decrease Diaphragmatic activity disappears in fourth plane

3 *Circulatory System* Bradycardia and arrhythmia may appear in third and fourth planes, but are not necessarily an index of depth of anesthesia Arterial tension is unchanged but may be elevated in any plane

Complications	*Reasons*
1 *Overdosage* respiratory failure precedes circulatory failure	Eye signs may not be fully established at outset but pupils may be

8 Beware of an extremely rapid or very slow pulse (below 60) Add ether if cardiac effects persist — Each is a sign of cardiac irritability Ether exerts a protective action on the heart

9 Insert an intratracheal airway if abdominal surgery is to be performed — The laryngeal spasm frequently prevents adequate ventilation and absorption of sufficient amount of agent for satisfactory relaxation

Changing to Ether

1 Light anesthesia If the anesthesia is light, empty the bag and fill with nitrous oxide 80% and oxygen 20% and start ether (ethylene and oxygen may be employed instead of nitrous oxide)

2 Deep anesthesia Begin to drop the ether as fast as the patient tolerates it Change to nitrous oxide or ethylene is not necessary

Comment	*Reason*
1 Do not add ether if the anesthesia is light without adding ethylene and oxygen	Ether tends to lighten the anesthesia further and causes a spasm of the larynx

Cyclopropane curare Cyclopropane provides analgesia and unconsciousness, curare relaxes the muscles Light cyclopropane anesthesia may thus be employed in major surgical procedures

1 Anesthetize patient as described above

2 Administer curare intravenously at the time the skin incision is made in 20 unit doses waiting 3 minutes between doses until desired muscle relaxation is obtained

3 Intubate (if necessary) to maintain a free airway

Comment

Other muscle relaxants may be used as described (see Part IV)

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VINYL ETHER

Description A highly volatile, inflammable liquid whose vapor is easily inhaled, quickly produces unconsciousness and surgical anesthesia The drug is an unsaturated ether

8 It does not enhance acidosis, elevate blood sugar, or decrease renal or hepatic function

9 It decreases tidal volume and produces quiet respiration

Disadvantages

1 It is expensive, particularly if a completely closed system is not employed

2 It increases cardiac irritability and causes arrythmias

3 The patient may pass to stage IV if one does not observe him closely

4 Muscle relaxation is secured with difficulty in some cases

5 It is inflammable, anesthetic concentrations are explosive when mixed with air or oxygen

6 It occasionally produces an elevation of blood pressure

7 Postanesthetic nausea and vomiting not unusual

Comment	*Reasons*
1 Decrease morphine approximately 1/3 to 1/2 of usual dose when administering premedication for cyclopropane anesthesia	Overpremedication enhances respiratory depression frequently observed with the drug
2 Do not allow the patient to recover until the skin is sutured and the dressing is in place	Patient reacts very rapidly, and may emerge from anesthesia before the operation is completed
3 Be prepared to restrain the patient on the stretcher or in the room	Excitement or emergence delirium may occur during the recovery period Administer morphine intravenously to relieve it
4 The gas may be used in uncomplicated hypertension without fear of increase of pressure or other deleterious effects	The hypertension appears to be more pronounced in subjects with normal blood pressure It may be due to a retention of carbon dioxide in the tissues
5 Employ the gas for short minor surgical procedures	Induction and recovery are rapid and anesthesia is easily induced and controlled by this agent
6 Treat any apnea whose cause is not determined as an *overdose* of the drug and institute artificial respiration immediately	Overdosage is dangerous because the drug is a cardiac depressant and cardiac failure may quickly follow respiratory failure
7 Do not administer epinephrine for any purpose during cyclopropane anesthesia	Irritability of cardiac automatic tissue is increased by both drugs Ventricular fibrillation or serious arrhythmias may occur if they are used together

2 Lubricate the skin with vaseline and apply the protector over the face and eyes in the manner described for ether

3 Apply mask arranged with stockinet or 6–10 layers of gauze (as for ethyl ether anesthesia)

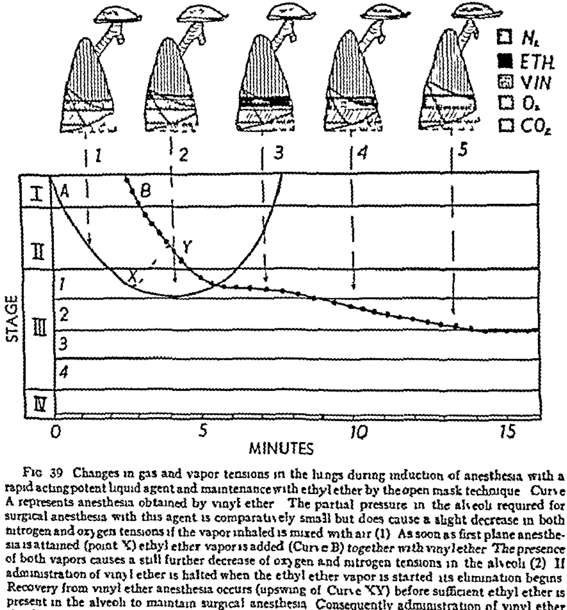

FIG 39 Changes in gas and vapor tensions in the lungs during induction of anesthesia with a rapid acting potent liquid agent and maintenance with ethyl ether by the open mask technique Curve A represents anesthesia obtained by vinyl ether The partial pressure in the alveoli required for surgical anesthesia with this agent is comparatively small but does cause a slight decrease in both nitrogen and oxygen tensions if the vapor inhaled is mixed with air (1) As soon as first plane anesthesia is attained (point X) ethyl ether vapor is added (Curve B) *together with vinyl ether* The presence of both vapors causes a still further decrease of oxygen and nitrogen tensions in the alveoli (2) If administration of vinyl ether is halted when the ethyl ether vapor is started its elimination begins Recovery from vinyl ether anesthesia occurs (upswing of Curve XY) before sufficient ethyl ether is present in the alveoli to maintain surgical anesthesia Consequently administration of vinyl ether should continue until enough ethyl ether is present in the alveoli to maintain surgical anesthesia (Y) The vinyl ether is quickly eliminated during the maintenance of ethyl ether anesthesia (3 4 5) Upswing of Curve A

The same principles apply to the use of other volatile rapid acting drugs (chloroform ethyl chloride) when used as a preliminary to ethyl ether

4 Commence to drop drug slowly on the mask, increasing the rate to 40 or 50 drops per minute Hold the tip of the dropper approximately one inch from the mask and drop the drug continuously at an even rate

5 As soon as patient passes into stage III, adjust rate of dropping according to the physiological requirements of the patient and the depth of anesthesia desired

Synonyms "Vinethene,"*—*divinyl ether*, or vinyl oxide

Uses

1 As preliminary agent to shorten the first and second stage of ether anesthesia
2 For anesthesia or analgesia for brief minor surgical procedures such as dental extractions, incision and drainage, reduction of fractures, obstetrics, etc
3 As a complemental agent to nitrous oxide, ethylene, or other inhalation anesthesia

Cost Relatively expensive—25 cc cost approximately 30 cents Usually available in 10, 25, or 50 cc bottles provided with metal dropper caps to facilitate use

Methods of Administration

1 *Open drop* This is the safest and simplest method of administration by inexperienced individuals and is the method recommended
2 *Semi-closed* This method allows use of the drug with other gases, particularly oxygen It is less expensive than the open method
3 *Closed* This method affords considerable saving and insures adequate oxygenation, but an even level of anesthesia is often maintained with difficulty by inexperienced individuals

Concentration

1 Analgesia 2% by volume or less in the alveoli
2 Anesthesia approximately 4% by volume in the alveoli
3 Respiratory failure 8–10% by volume in the alveoli

Premedication May be administered without premedication, but morphine and atropine or morphine and scopolamine in doses similar to those employed for ether are preferred (see premedication)

Materials The same equipment required for ethyl ether by the open drop technique may be employed

1 Artificial airway
2 Mask and 6–10 layers of gauze
3 Towels
4 Vaseline or cold cream
5 Eye protector
6 Bottle of vinethene with dropper cap
7 Suction equipment

Technique of Open Drop Method (see Fig 39)

1 Arrange patient in manner described for ether by the open drop technique

* A patented name for vinyl ether containing 4% absolute ethyl alcohol and 01% alpha phenyl naphthylamine The latter substance acts as a stabilizer

2 Lubricate the skin with vaseline and apply the protector over the face and eyes in the manner described for ether

3 Apply mask arranged with stockinet or 6–10 layers of gauze (as for ethyl ether anesthesia)

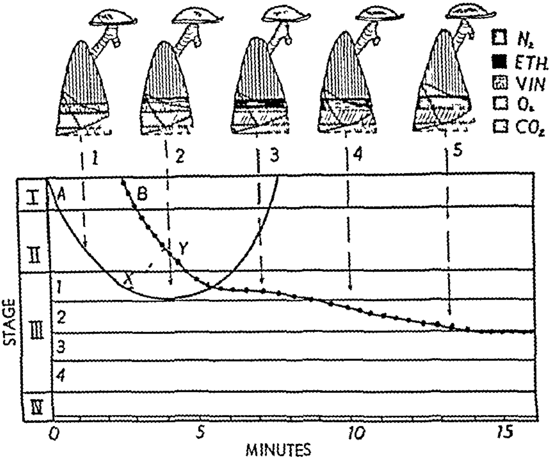

FIG 39 Changes in gas and vapor tensions in the lungs during induction of anesthesia with a rapid acting potent liquid agent and maintenance with ethyl ether by the open mask technique Curve A represents anesthesia obtained by vinyl ether The partial pressure in the alveoli required for surgical anesthesia with this agent is comparatively small but does cause a slight decrease in both nitrogen and oxygen tensions if the vapor inhaled is mixed with air (1) As soon as first plane anesthesia is attained (point X) ethyl ether vapor is added (Curve B) together with vinyl ether The presence of both vapors causes a still further decrease of oxygen and nitrogen tensions in the alveoli (2) If administration of vinyl ether is halted when the ethyl ether vapor is started its elimination begins Recovery from vinyl ether anesthesia occurs (upswing of Curve XY) before sufficient ethyl ether is present in the alveoli to maintain surgical anesthesia Consequently administration of vinyl ether should continue until enough ethyl ether is present in the alveoli to maintain surgical anesthesia (Y) The vinyl ether is quickly eliminated during the maintenance of ethyl ether anesthesia (3 4 5) Upswing of Curve A

The same principles apply to the use of other volatile rapid acting drugs (chloroform ethyl chloride) when used as a preliminary to ethyl ether

4 Commence to drop drug slowly on the mask, increasing the rate to 40 or 50 drops per minute Hold the tip of the dropper approximately one inch from the mask and drop the drug continuously at an even rate

5 As soon as patient passes into stage III, adjust rate of dropping according to the physiological requirements of the patient and the depth of anesthesia desired

Vinethene-Ether Sequence

1 As soon as the patient is in stage III, begin dropping ether as rapidly as patient allows without soaking the mask If patient becomes "light" or coughs, add vinethene until cough disappears and then resume ether
2 Continue the anesthesia after the ether is begun as described for ether

Signs of Anesthesia

1 *Respiratory system* Rate of respiratory movements may increase, and amplitude decreases in light anesthesia, otherwise it is the same as for ethyl ether in all stages Watch respiration closely Respiration fails before circulation
2 *Nervous system* Ocular movements remain active until third plane is attained Eye signs are not as reliable a guide as they are for ethyl ether Rhythmic rolling movements and horizontal nystagmus are commonly observed during induction and recovery
3 *Circulatory system* Changes are similar to ether

Advantages

1 The induction and recovery are rapid and pleasant The period usually occupies 2–3 minutes
2 It may be administered by means of simple apparatus or even the use of a piece of gauze as a vaporizer
3 The low partial pressure necessary for surgical anesthesia allows use of air as a vehicle for the vapor
4 It does not affect the circulatory system
5 It does not depress respiration
6 Postanesthetic nausea and vomiting are not common
7 *The vapors may be inhaled directly without causing discomfort*
8 Reflexes quickly return Postanesthetic depressions are slight or absent

Disadvantages

1 It is not chemically stable and requires a preservative and protection from light, heat, and air to maintain its stability
2 It is highly volatile (B P 28°C) Evaporation occurs readily at room temperature (Keep tightly stoppered)
3 It is irritating to mucous membranes of respiratory tract in anesthetic concentration
4 It frequently causes copious salivation and secretion of mucus
5 The depth of anesthesia is difficult to maintain at a constant level
6 The vapor forms explosive mixtures with air or oxygen
7 Muscle relaxation is inadequate for major surgery
8 It is expensive, *in comparison to other volatile liquids*
9 It may cause burns or blisters to skin

10 It causes physiological disturbances, such as elevation of blood sugar and decrease in CO_2 combining power, but not so profoundly as ethyl ether

11 It may cause hepatic or renal damage, particularly if administered over a long period of time or if administration is accompanied by anoxia

Nitrous Oxide Oxygen Fortified with Vinethene

Materials

1 Either the apparatus which permits the use of pre mixed oxygen nitrous oxide mixtures to be delivered on demand (McKesson) or standard type (Heidbrink, Foregger) may be used

2 Special vaporizer designed for vinethene Usually a squat, wide mouth jar with wick

Procedure

1 Adjust the flow of nitrous oxide to deliver a 75%–25% oxygen mixture at the rate of 6 liter flow On demand (McKesson) apparatus set positive pressure gauge for 3–4 mm Hg and mixing device for 75% N_2O and 25% O_2

2 Adjust mask to the patient's face and commence flow of gas

3 Open the exhalation valve partially to allow excess gas to escape Permit the patient to breathe this mixture for 3 to 4 minutes, then gradually add vinethene until the superficial reflexes disappear and patient is in stage 3

4 Turn on carbon dioxide absorber and continue anesthesia with this mixture

Comment

For lengthly procedures decrease opening in exhalation valve reduce flow of nitrous oxide to 2 liters and increase oxygen to 850 cc and vinethene in proportion to maintain surgical anesthesia

Contra Indications

1 For long operations or operations of undetermined duration

2 For procedures requiring muscle relaxation

3 The presence of hepatic or renal insufficiency or diseases

4 The presence of acute infections of the respiratory tract

5 Procedures requiring use of cautery or other types of apparatus which may be a source of ignition

Complications	*Cause*
1 Respiratory obstruction	It is usually the result of salivation and secretion of mucus Pre-

	vent by adequate premedication of atropine or scopolamine
2 Overdosage	The drug is administered too rapidly Respiratory movements cease before circulation fails Treat with artificial respiration
3 Postanesthetic nausea and vomiting	The cause is probably the same as with other anesthetic drugs and procedures
4 Headache	The cause is not determined Not common or serious if it occurs
5 Convulsions	These are probably due to the effect of the drug upon the central nervous system They occur less frequently if premedication of morphine and scopolamine is employed Control them with ultrashort acting barbiturates intra venously administered

Comment	*Reasons*
1 Do not induce anesthesia until all preparations for surgery have been made	The period of anesthesia should be as short as possible The use of the drug for periods exceeding thirty minutes is not recommended
2 Regulate the number and size of the drops by adjusting the cap on the dropper	No vent is required on the bottle because the drug is so volatile that the vapor forces it out of the bottle
3 Use the semi open method for anesthesia in adults	Vaporization occurs so rapidly it may not be adequate in robust subjects
4 Store the drug in a cool place away from acids and fumes	Heat and acids hasten its deteriora tion
5 Do not use the drug beyond its expiration date	The drug is stable in the container for two years
6 Select vinyl ether in preference to ethyl chloride as an inhalation anesthetic agent	The scope and utility of the two agents are similar, but the cardiac effects of ethyl chloride are absent with vinyl ether
7 When this drug is employed do not tolerate anoxia or obstruction under any circumstances	The possibility of hepatic damage is markedly enhanced by lack of oxygen
8 Do not administer the drug too rapidly or in too high a concen tration	Salivation and secretion of mucus are more pronounced The pos sibility of overdosage is increased
9 Drop the drug continuously on	The drug is so volatile that inter-

	the mask during induction and maintenance of anesthesia	mittent dropping causes uneven anesthesia
10	Do not allow the liquid to drop on or come into contact with the skin	Burns and blisters may result, particularly if pressure is applied to the area involved

Variations in Technique

1 *For Analgesia* Proceed with the induction until patient feels a sensation of dizziness, then decrease the rate of administration as stage II is approached Instruct the patient to raise his hand when he feels pain during the surgery and increase the rate of administration

2 *For Anesthesia by Closed Methods* Place the vinyl ether in the ether vaporizer and allow oxygen or mixtures of oxygen and nitrous oxide or ethylene to flow over the liquid or bubble gently through it Proceed as described

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Martin, S J, and Rovenstine, E A Vinethene, Recent Laboratory and Clinical Evaluation Anesthesiology, *2*, 285–299, May, 1941

Ravdin and others Divinyl Ether Jour A M A, *108*, 1163, April 1937

Ethyl Chloride

Description A highly volatile, inflammable liquid whose vapor is pleasant smelling, easily inhaled and quickly produces unconsciousness and surgical anesthesia and analgesia The drug is a halogenated hydrocarbon

Synonym "Kelene"

Uses

1 As an induction agent to shorten the first and second stage of ether administered by the open mask techniques

2 To secure anesthesia and analgesia for operations or minor surgical procedures of not more than several minutes duration

Cost Relatively inexpensive (100 cc cost approximately 50 cents)

Methods of Administration

1 *Open drop* Safest and simplest and the recommended technique for the novice

2 *Closed* This method allows the use of oxygen and affords considerable saving of drug, but the depth of anesthesia is difficult to maintain at a constant level Not recommended for inexperienced individuals

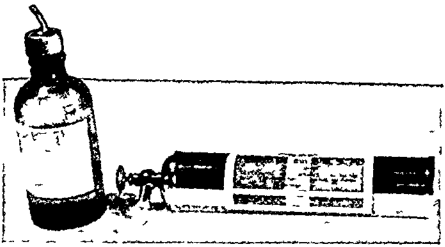

FIG 40 Dropper bottle for vinyl ether with an adjustable tip to control the rate and size of drops, and ampule for storage of ethyl chloride

Concentration

1 Analgesia 2 or 3% by volume in the alveoli
2 Anesthesia 5–6% by volume in the alveoli
3 Respiratory failure not determined

Premedication Morphine and scopolamine or morphine and atropine in doses similar to those employed for ether anesthesia

Materials The same equipment employed for ethyl ether by the open drop technique

1 Artificial airway
2 Wire mask with 6–10 layers of gauze or a stockinet
3 Towels
4 Eye shield
5 Ethyl chloride The drug is usually packed in metal or glass ampules equipped with a capped nozzle (Fig 40) The liquid may be sprayed or dropped from the nozzle by manipulation of the cap

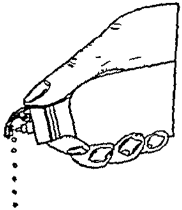

FIG 41 Manner of dropping drug for inhalation anesthesia by the open mask technique is shown.

Technique of Open Drop Method (see Fig 41)

1 Arrange patient in a manner similar to that described for ether anesthesia by the open drop method
2 Protect the face and eyes Apply and hold the mask as described for ether anesthesia
3 Hold the ampule in the right hand several inches above the mask and tilt it so that the liquid gravitates to the outlet Lift the cap from the nozzle sufficiently to allow the stream of liquid to strike and glance off it to the mask in form of drops (do not spray) Hold nozzle of ampule several inches from the mask (Fig 41)

4 Allow a few drops of the drug to fall upon the mask to accustom patient to odor
5 Ask patient to begin counting out loud (if he is cooperative)
6 Commence to drop the drug at the rate of one drop every three or four seconds and gradually increase the rate to one every two or three seconds
7 As soon as consciousness is lost (between one to two minutes) change the rate but continue to drop the drug until a hyperpnea develops
8 Quickly begin to drop ether as rapidly as the patient tolerates the drug

Signs of Anesthesia These are similar to those described for vinyl ether

Advantages

1 The period of induction and recovery are rapid Usually occupy several minutes
2 It shortens the length of stages I and II of ether anesthesia when used as a preliminary to it
3 It may be administered with a simple apparatus
4 The low partial pressure required for surgical anesthesia allows the use of air as a vehicle and source of oxygen
5 It does not cause respiratory depression
6 It is pleasant to inhale and is not irritating to membranes of the respiratory tract
7 It is chemically stable
8 It causes little postanesthetic nausea and vomiting

Disadvantages

1 It possesses a narrow margin of safety
2 It depresses the circulatory system and frequently causes cardiac failure Circulation may fail before respiration
3 It forms explosive mixtures when mixed with air or oxygen
4 It frequently causes stridor or muscle rigidity
5 The depth of anesthesia is difficult to maintain at a constant level
6 It may cause renal or hepatic damage if administered over a prolonged period of time
7 A cold vapor is inhaled when it is employed, this may be irritating

Contraindications

1 The presence of any circulatory disturbances or disease
2 Procedures requiring more than several minutes for completion
3 The presence of acute respiratory infections
4 Procedures requiring use of cautery or other apparatus which may be a source of ignition

Complications	*Reasons*
1 Stridor or laryngeal spasm	These are usually of reflex origin Discontinue the drug and adminis-

	ter oxygen under slight positive pressure to relieve it
2 Syncope	It is caused by cardiac failure from overdosage or the depressant action of the drug upon the heart
3 Respiratory failure	It is due to overdosage Institute artificial respiration immediately
4 Spasm of muscles Usually manifested by opisthotonus, rigidity, or twitchings	Discontinue the drug immediately, remove mask from face, and allow the patient to recover from anesthesia

Comment	*Reasons*
1 Avoid use of this drug for inhalation anesthesia unless absolutely necessary	The deleterious cardiac effects render this a dangerous drug even when administered by expert individuals
2 Remember that a latent phase of 30 or 40 seconds follows cessation of administration of ethyl chloride During this interval the patient becomes more deeply anesthetized	The drug in the lungs continues to be absorbed into the blood even though vaporization has ceased at the mask
3 Do not spray the drug on mask	The spray is so fine that it passes through the gauze and causes excitement if it falls on the patient's face High concentrations collect under the mask if the spray passes through it
4 Do not wrap towels about the mask	The drug is not sufficiently diluted with air and a dangerously high concentration collects around the mask
5 Begin dropping ether as soon as the patient is narcotized by the ethyl chloride	Recovery begins almost immediately after cessation of administration of ethyl chloride The drug is eliminated even though ether is being inhaled
6 Remove the frost which collects on mask	Water vapor of exhaled air freezes because a low temperature is produced by the vaporization of ethyl chloride The frost may cause obstruction
7 Do not return to the administration of ethyl chloride once the administration of ether has been instituted	The possibility of overdosage is increased if this is done

8 Do not tolerate anoxia or respiratory obstruction under any circumstances	Cardiac irritability caused by this drug is enhanced by anoxia Ventricular fibrillation may follow
9 Drop the drug continuously onto the mask during induction period and maintenance	The drug is so volatile that intermittent dropping results in an uneven plane of anesthesia
10 Do not administer epinephrine in conjunction with ethyl chloride	Both drugs increase irritability of cardiac tissues

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Adriani, J The Pharmacology of Anesthetic Drugs 3rd Ed Pp 46–48 Charles C Thomas Springfield, Ill, 1953

Chloroform

Description Chloroform is a colorless, volatile liquid whose vapor is sweet smelling, easily inhaled, and non inflammable Chloroform is the most potent inhalation anesthetic agent available

Uses

1 For all types of surgery in which a potent anesthetic agent is required
2 As preliminary induction agent for shortening the first and second stages of ether anesthesia
3 As an analgesic agent for obstetrical and other uses
4 For operations in which a non inflammable inhalation anesthetic is necessary

Cost Relatively inexpensive

Methods of Administration

1 *Open drop* This is the most commonly employed, simplest, and safest technique and the one which is recommended
2 *Semi closed* This technique allows the drug to be administered with oxygen or other gases
3 *Closed* This technique allows rebreathing with high oxygen concentration but is only recommended for experienced individuals

Concentration

1 Analgesia less than 1% by volume in the alveoli
2 Anesthesia approximately 1 5% by volume in the alveoli
3 Respiratory failure 2% by volume in the alveoli

Premedication Morphine and atropine or morphine and scopolamine in the usual therapeutic doses employed for ether (see premedication)

Materials

1 A large mask provided with four to six layers of gauze or a stockinet The edge should be cut to the shape of the mask

2 An artificial airway
3 A protecter for the eyes
4 Chloroform in a bottle equipped with dropper
5 Petrolatum or cold cream for the skin
6 Castor oil for the eye and a dropper
7 Inhaler to supply oxygen and artificial respiration if necessary
8 Nasal catheter for the oxygen

Technique of Open Method

1 Arrange and prepare the patient in the same manner described for ether by the open method
2 Place the eye protector over eyes and lubricate the face well with petrolatum or cold cream
3 Apply the mask to the face and hold it in the same manner as described for ether by the open method
4 Begin to drop chloroform on the mask as rapidly as patient tolerates it Start with three drops the first minute and double the rate each succeeding minute for the first four or five minutes
5 As soon as patient is in stage III, instill two drops of castor oil into each eye
6 Insert a nasal catheter into one nostril and replace the mask (see page 10) Supply oxygen at approximately 1000 cc per minute from inhaler
7 Continue to drop the drug at rate necessary for desired plane of anesthesia

Signs of Anesthesia The signs of anesthesia are in general similar to those outlined under Judging Depth of Anesthesia

Advantages of Chloroform

1 It is the most potent inhalation anesthetic agent available The relaxation it yields is excellent
2 The period of induction is rapid and does not necessitate the use of a preliminary agent such as nitrous oxide or ethylene
3 It forms non-inflammable mixtures with air or oxygen
4 It possesses a degree of volatility (B P 61°C) which allows its use in the tropics or warm climates
5 It may be administered by means of very simple equipment
6 It does not unduly stimulate respiration A "quiet abdomen" follows
7 Its extreme potency and the low partial pressure necessary for anesthesia allow the use of air as a vehicle
8 It is chemically stable if preserved by alcohol away from heat, air, or light

Disadvantages

1 It possesses a narrow margin of safety The transition through the upper to lower stages of anesthesia is rapid
2 It may cause hepatitis to appear postoperatively
3 It may cause severe derangement of liver function, without hepatitis
4 It causes cardiac depression which is manifested by syncope, ventricular fibrillation, arrhythmias or other disturbances
5 It causes serious biochemical disturbances, such as elevation of blood sugar, decrease in acid base balance or dehydration
6 It may decompose if exposed to flames or cautery in the presence of air to form phosgene
7 Its elimination is slow
8 It is frequently accompanied by postanesthetic nausea and vomiting

Contra-Indications	*Reasons*
1 Diseases of the heart	Chloroform increases irritability of cardiac automatic tissue
2 Hypertension or hypotension or "shock"	The vasomotor center is depressed, and cardiac output is decreased by the drug
3 Diabetes mellitus or acidosis from any cause	Carbon dioxide combining power is decreased and blood sugar is elevated during anesthesia
4 Diseases of the liver	It decreases liver function and predisposes to or causes hepatitis
5 Diseases of the kidney	It causes oliguria or anuria
6 Acute or chronic diseases of the respiratory tract	It increases production of mucus and other secretions which disseminate infection from one part of the respiratory tract to another

Comment	*Reasons*
1 Never allow liquid chloroform to come into contact with the skin	If chloroform remains in contact with the skin it causes burns or blisters, particularly if pressure is applied to the area
2 Do not tolerate anoxia during the administration of chloroform Supply oxygen if possible	The possibility of liver damage is increased Anoxia augments cardiac irritability and hastens cardiac failure and shock
3 Do not expose chloroform vapor to naked flames or sparks	Phosgene, which is irritating to pulmonary epithelium, may form Pulmonary edema occurs
4 Drop the drug slowly and at a constant rate rather than inter-	This insures a constant level of anesthesia Overdosage can only

	mittently	be avoided by extreme care
5	Do not administer chloroform to starved, debilitated, or emaciated individuals	The possibility of hepatitis is greater in these subjects Preoperative administration of glucose is desirable if possible
6	Do not use epinephrine for any purpose during chloroform anesthesia	Both drugs increase cardiac irritability Ventricular fibrillation may result
7	Do not omit premedication Administer both an opium and a belladonna derivative	Avoid any and all excitement Epinephrine may be liberated into the blood during the period of excitement and the patient may die of ventricular fibrillation during the induction
8	Palpate the pulse continuously and record blood pressure readings frequently	Circulatory failure may precede respiratory failure at any time
9	Remember that as the operation continues smaller amounts of drug will be necessary to maintain the desired depth of anesthesia	As time goes on an equilibrium becomes established between the drug in blood and in the tissues
10	Do not delay instituting artificial respiration in the event respiratory failure occurs	The margin between respiratory failure and circulatory failure is narrow Delays may be fatal
11	Decrease the rate of administration should the patient suddenly breathe deeply Raise the mask from the face if the patient holds his breath	The amount of drug necessary for anesthesia is so small that a sudden concentrated breathful may lead to overdosage and cardiac arrest
12	Do not stimulate the patient in any way during the induction and recovery periods	Ventricular fibrillation may occur as the result of excitement due to the probable release of epinephrine which will favor the onset of ventricular fibrillation
13	Discontinue the drug if the pulse becomes slow (50 or less) or irregular	Such changes indicate cardiac depression, irritability, or shift of the pace maker
14	Never pour chloroform onto the mask	The danger of overdosage is ever present and is increased by such a technique

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Goodman, L, and Gilman A *The Pharmacological Basis of Therapeutics* Pp 75–93 The Macmillan Co New York, 1955

TRICHLORETHYLENE

Description Trichlorethylene is a colorless, slowly volatilizing liquid whose vapor is sweet smelling, easily inhaled and not inflammable The odor resembles that of chloroform

Synonyms Trilene, trimar

Uses

1 As an analgesic agent for obstetrics skin grafting and other minor forms of surgery
2 To fortify nitrous oxide
3 For operations in which a non inflammable inhalation anesthetic may be necessary The use of the drug for general anesthesia has been abandoned

Cost Relatively inexpensive, approximately 1 cent per cc

Methods of Administration

1 Open drop This is the most commonly employed, simplest technique and the one which is recommended for surgical anesthesia
2 Semi closed This technique allows the drug to be administered with oxygen or nitrous oxide
3 Closed This technique cannot be used because the drug is unstable in the presence of soda lime

Concentration

1 Analgesia—less than 1% by volume in the alveoli
2 Anesthesia—approximately 4% by volume in the alveoli
3 Respiratory failure—exact concentration not established

Premedication

Morphine combined with atropine, bellafoline or scopolamine in the therapeutic doses recommended for ether anesthesia (see premedication)

Materials

1 A large open drop mask provided with 4 to 6 layers of gauze or stockinet The edge should be cut to fit the shape of the mask
2 An artificial airway
3 A protector for the eyes
4 Trichlorethylene in a bottle equipped with a dropper
5 Petrolatum or cold cream for the skin
6 Castor oil for the eyes and a dropper
7 Inhaler to supply oxygen and artificial respiration if necessary
8 Nasal catheter for oxygen and oxygen supply

Technique of the Open Method

1 Arrange and prepare the patient in the same manner described for ether by the open method
2 Place the eye protector over the eyes and lubricate the face well with petrolatum or cold cream
3 Apply the mask to the face and hold it in the same manner as described for ether by the open method
4 Begin to drop the trichlorethylene on the mask as rapidly as the patient tolerates it Start with two or three drops the first half minute and double the rate each succeeding minute for the first four or five minutes
5 As soon as patient is in stage III, instill two drops of castor oil into each eye
6 Insert a nasal catheter into one nostril and replace the mask Supply oxygen at approximately 1000 cc per minute from the inhaler
7 Continue to drop the drug at a rate necessary for the desired depth of anesthesia

Signs of Anesthesia

The signs of anesthesia are in general similar to those outlined under Judging depths of anesthesia

Complications

1 Tachypnea This is due to stimulation of the alveolar nerve endings and indicate a dangerous intense vagal stimulation
2 Salivation This occurs frequently when premedication is not used
3 Cardiac irregularities The drug is like chloroform in its behavior on the heart
4 Poor relaxation Absorption is slow

Advantages of Trichlorethylene

1 It may be administered by means of simple equipment
2 It is a potent analgesic agent which can be administered by simple means
3 The low partial pressure necessary for anesthesia allows the use of air as a vehicle
4 It is accompanied by little post anesthetic nausea and vomiting
5 In concentrations less than 10% it forms nonflammable mixtures with air or oxygen
6 It is inexpensive

Disadvantages

1 It causes cardiac depression manifested by arrhythmias
2 It is decomposed in the presence of soda lime and cannot be used in the closed system
3 Induction is slow
4 It may cause derangement of liver function
5 It may be confused with chloroform because it possesses a chloroform-like odor
6 It volatilizes slowly This contributes to the slow induction
7 It causes a very rapid rate of respiration, sometimes up to 50 or 60 per minute
8 Its margin of safety is somewhat like that of chloroform when used for surgical anesthesia
9 It cannot be used in the closed system Toxic products form
10 Muscle relaxation is poor
11 It may cause burns on the skin

Comment	*Reason*
1 The drug is not recommended for surgical anesthesia	1 The drug induces deleterious cardiac effects, the effects on respiration are undesirable and relaxation is poor
2 Do not use the drug in the closed system	2 It is not stable in the presence of soda lime
3 Do not expose the vapor to flames or sparks	3 Phosgene which is irritating to the pulmonary epithelium may form and pulmonary edema may occur
4 Drop the drug slowly at a constant rate rather than intermittently	4 This insures a constant level of anesthesia Overdosage can thus be avoided
5 Do not administer to starved, debiliated or emaciated individuals	5 The possibility of hepatitis is greater in these subjects Preoperative administration of glucose is desirable
6 Do not use epinephrine during the anesthetic	6 Epinephrine increases cardiac irritability and causes serious arrhythmias
7 Discontinue the drug if the pulse becomes slow or irregular	7 Such changes indicate cardiac depression, irritability or shift of the pace maker
8 Never pour trichlorethylene on the mask	8 The danger of over dosage is ever present, and increased by such a technique
9 Discontinue administration if tachypnea occurs	9 This indicates possible intense vagal stimulation

Contra-Indications

1 Diseases of the heart	1 Trichlorethylene increases irritability of the cardiac automatic tissue
2 Hypotensive states	2 The drug may depress the vasomotor center and affects the heart
3 Acidosis from any cause	3 Carbon dioxide combining power may be elevated
4 Diseases of the liver	4 The drug is a halogenated hydrocarbon and these compounds predispose to hepatitis
5 Diseases of the kidney	5 Causes decrease in urinary output
6 Acute or chronic disease of the respiratory tract	6 The drug tends to produce mucus and other secretions which may disseminate infection from one part of the respiratory tract to the other

Variations in Technique

1 For analgesia Proceed with the induction until the patient feels a sensation of dizziness, then decrease the rate of administration as stage II is approached
2 Instruct the patient to raise his hand when he feels pain during the surgery and increase the rate of administration

Analgesia Using the Cyprane or Duke Inhaler

Description The Cyprane and the Duke inhalers (Figs 42 and 43) are devices which can be held by the patient for the self administration of vapors mixed with air Each consists of a cylindrical container attached to a mask A device for evaporation of the volatile liquid is in the cylindrical portion of the container Air drawn by the patient over the vaporizer is mixed with the vapor, passes through a valve into the mask The gas is then exhaled through another valve on top the mask Only the vapor and air in the mask is rebreathed

Technique

1 Load the chamber with the trichlorethylene to saturate wick (15 cc)
2 Empty excess liquid
3 Attach mask to face
4 Set vaporizer at minimum
5 Commence administration and gradually rotate vapor control from

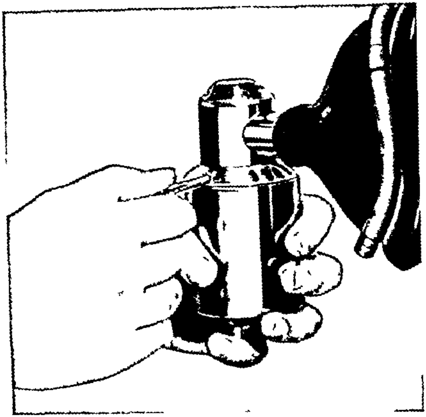

Fig 42 A Cyprane inhaler for self administration of vapors of volatile liquids

Fig 42 B Duke inhaler for self administration of vapors of volatile liquids

minimum mark towards maximum until optimum concentration is reached

6 Lock device at this point

Comment

The wick holds about 15 cc

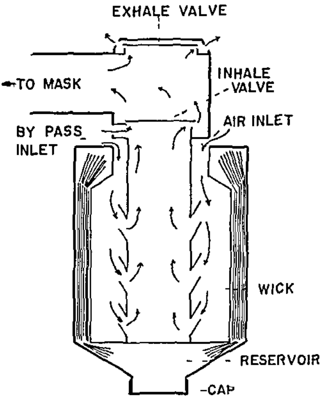

FIG 43 Cross section of semi closed inhaler (Duke, Cyprane type) used for administering mixtures of air and volatile liquids On inspiration air is drawn through the ports over the surface of the wick which lines the cylindrical container, mixes with vapor which volatilizes from the wick and passes through the inhale valve to the mask On expiration the exhaled gases pass from the mask through the exhalation valve Thus with the exception of the gases in the mask there is no rebreathing The adjustable ports permit the by passing of the anesthetic so that the percentage of vapor and air can be varied The liquid is stored in the bottom of the container

NITROUS OXIDE—TRICHLORETHYLENE OXYGEN

Material Same as for nitrous oxide-vinethene

Premedication Morphine—scopolamine, hyoscyamine or atropine

Procedure Same as outlined for nitrous oxide oxygen vinethene, except that special vaporizing jar without a wick must be used for trichlorethylene No rebreathing must be permitted

1 Adjust mask to the patient's face
2 *Commence a flow of 6 to 8 liters of nitrous oxide 75%–25% oxygen*
3 Allow patient to breathe this mixture for several minutes until maximum depth the mixture can give is attained It is uncommon to go beyond second stage

4 Increase vaporizer control gradually trichlorethylene and permit vapor to mix with nitrous oxide until patient passes into 3rd stage Turn in trichlorethylene slowly
5 Maintain concentration at this point

Comment	*Reason*
1 Do not use carbon dioxide absorber	Soda lime decomposes trichlorethylene and forms dangerous biproducts
2 Use a high flow of gas mixture with adequate oxygen	Carbon dioxide must be washed out of the inhaler It will not be removed unless the tidal exchange of the patient is flown into apparatus
3 Do not maintain anesthesia below first plane	Cardiac irregularities and tachypnea may develop
4 If demand type apparatus is used merely set mixing device for 75% nitrous oxide 25% oxygen and add trichlorethylene as described above	The tidal exchange of the patient will be supplied by the apparatus
5 Do not use vaporizer with wicks of type used for ether	The concentration of vapor delivered will be excessive

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ARTIFICIAL AIRWAYS

Definition Artificial airways are rigid or semi rigid tubes composed of rubber or metal They are designed to fit into the upper portions of the respiratory tract

Purpose

1 They provide an unimpeded pathway for respired gases
2 They facilitate removal of secretions from the respiratory tract
3 They conduct anesthetic mixtures to the respiratory tract

Types

1 *Oropharyngeal* These are metal or rubber tubes which are inserted through the mouth into the pharynx
2 *Nasopharyngeal* These are soft rubber catheters which are inserted into the pharynx through the nostrils
3 *Orotracheal* These are rubber, metal, or silk woven catheters which are inserted into the trachea through the mouth, usually by the aid of a laryngoscope

4 *Nasotracheal* These are soft rubber catheters which are inserted through the nostrils into the trachea

Oropharyngeal Airways

Description Oropharyngeal airways are tubes shaped in such a manner that they conform to the curvature of the palate They extend from the lips to the pharynx and serve either as pathways for respired gases or support the tongue and pharyngeal structures so that the natural airway remains patent (Fig 44)

Types

1 *All metal* These are curved flat tubes with a flange or disk at the oral end to fit over the lips Many designs are available, all of which accomplish the same purpose (Fig 45)
2 *Wire cage type* These are similar in design to the metal type except that they are woven from wire (Fig 45)
3 *All rubber* These are curved tubes of semi hard rubber similar in design to the metal type They serve the same purpose and are introduced in the same manner (Fig 45)

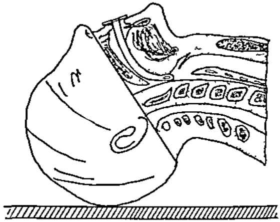


FIG 44 Oral pharyngeal airway in situ Note that the airway does not extend beyond the hypo pharynx

Advantages of metal airways

a They are easily cleaned and sterilized by boiling
b They are permanent, and not damaged by ordinary wear
c They are inserted and removed readily in event of spasticity of muscles of the jaw

Disadvantages of metal airways

a They may cause trauma to the lips, tongue, pharynx, or teeth

Advantages of rubber airways

a The possibility of trauma is minimized when used

Disadvantages of rubber airways

a They often acquire obnoxious odors which are difficult to eliminate from the rubber
b They are difficult to insert or remove in patients whose jaws are tightly clamped because of spasticity of muscles

c They are not permanent, rubber deteriorates
d They are not conveniently sterilized by boiling

Comment

Airways are available in many sizes The proper size must be selected for the individual patient

Procedure for Insertion of Oropharyngeal Airways	*Reasons*
1 Select an airway of the proper size for the subject and place it within ready reach of the right hand	Airways of improper size either may not adequately support relaxed structures or they may extend too far into the hypopharnyx Obstruction may result in either case
2 Turn off ether or other anesthetic gases (oxygen at metabolic rate may continue to flow)	The concentration of the drug in the inhaler may become excessive if gases or vapors continue to flow during the manipulation
3 Unstrap the mask, but continue to hold it firmly to the face until all preparations are complete	The patient should breathe room air for as short an interval as possible to prevent lightening of anesthesia and return of the pharyngeal reflex
4 Close the obturator and lift the mask from the face	The obturator prevents loss of the mixture of gas from inhaler Anesthesia may thus be resumed without forming a new mixture
5 Grasp the airway in the right hand and hold it in a horizontal position so that pharyngeal end rests on the lip (Fig 46)	The airway is thus placed in a position for a rotary motion which is necessary to easily slip the tube into the pharynx
6 Push lower jaw foward, insert a tongue blade or thumb to hold the tongue against floor of the mouth	The tongue is thus prevented from falling back into the pharynx and causing obstruction
7 Swing the curved portion of the airway into the pharynx using a rotary motion (Fig 46)	The airway follows the curvature of the palate and slips into the pharynx without causing the tongue to drop into the pharynx
8 Replace the mask on the face and open obturator	The patient should resume breathing the anesthetic mixture as soon as possible after insertion of the airway to prevent lightening of anesthesia
9 Ascertain that the airway is clear	The improperly inserted airway

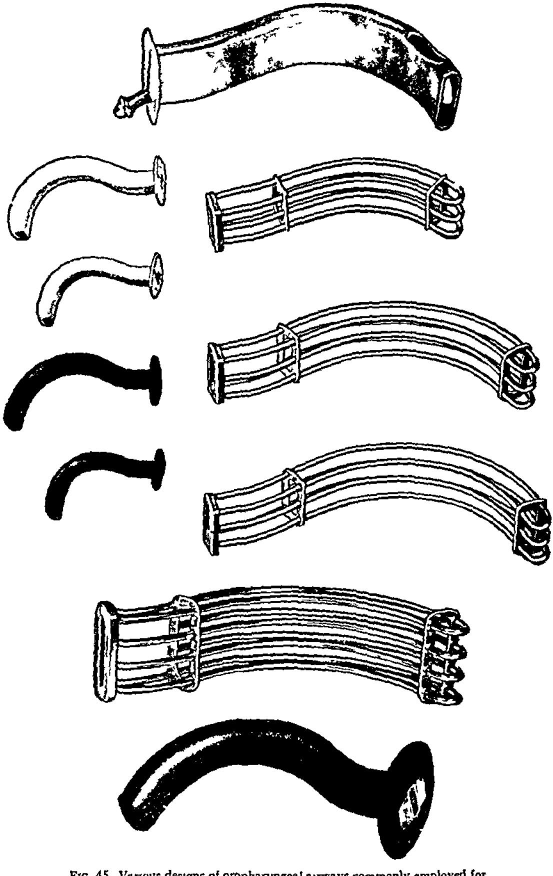


FIG 45 Various designs of oropharyngeal airways commonly employed for inhalation anesthesia (Courtesy of Richard Foregger Ph D)

and fasten the mask in usual manner	often increases obstruction
10 Secure a snug fit and resume flow of gases and vapors into inhaler	More agent is invariably necessary because some lightening occurs

Comment	*Reasons*
1 Be sure that the patient is in stage III before attempting to insert the airway	The pharyngeal reflex which is active in stages I and II disappears in plane 1 of stage III

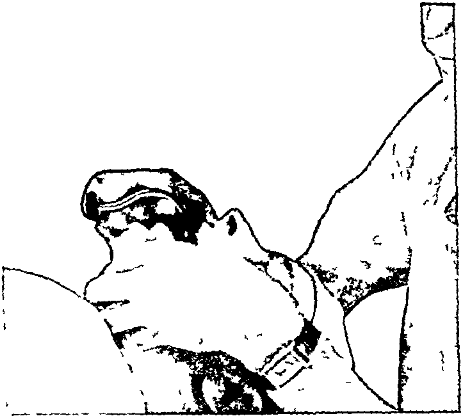


FIG 46 Insertion of oropharyngeal airway The airway is held in a horizontal position and swept into the pharynx with a rotary motion.

2 Delay the introduction of airways as long as possible	The possibility of return of the pharyngeal reflex decreases as the anesthetic progresses and becomes deeper
3 Be positive the patient breathes freely after the airway is inserted	If respiratory movements are absent or not in proportion to the tidal exchange, it is because a Patient became "too light" and pharyngeal reflex returns and the breath is held due to reflex stimulation Remove airway

	immediately or emesis may follow
	b The airway is not inserted correctly because the tongue is folded in the pharynx and is causing obstruction (Fig 47) Remove or replace it properly
4 Arrange flange of airways so that it rests over the lips	Laceration or other trauma to soft tissues may result if this is not done
5 Never attempt to insert an airway by holding it in a vertical position	Obstruction may result from folding of the tongue in the posterior pharynx

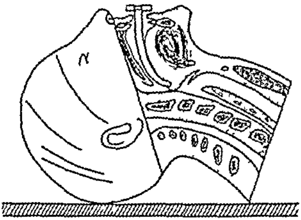


FIG 47 Improper use of oropharyngeal airways may result in complete obstruction to respiration The tongue is relaxed and has dropped into the pharynx The airway is too small to relieve the obstruction

6 Be positive the flange of the airway is completely covered by the mask	A leak occurs if any overlapping is present
7 Never use an airway to pry the jaws apart in the event of spasticity of muscles	The teeth may be damaged If necessary, insert the thumb or index finger at side of the mouth behind molar teeth and exert force there
8 Remove airways which have become filled with mucus or secretions	Mucus causes obstruction to respiration
9 Never begin an anesthetic without having an airway of proper size within immediate reach	Respiratory failure or obstruction may occur at the most unexpected times even in apparently simple cases

NASOPHARYNGEAL AIRWAYS

Description Nasopharyngeal airways consist of soft rubber catheters which extend from the nostrils to nasopharynx and act as pathways for respired gases (Fig 49)

Features of Nasal Airways (Figs 48 and 49)

1 They are composed of thin walled latex or gum rubber tubing
2 Their diameters vary from 26–32 French
3 The pharyngeal end is beveled laterally
4 The nasal end is cut transversely and a safety pin is inserted through it to prevent its slipping all the way into the nose
5 The length is usually one inch in addition to the distance from the tragus of the ear to tip of the patient's nostril

FIG 48 Nasal pharyngeal airway Note the funnel shaped slip joint to prevent the catheter from sliding into the nasopharynx

Advantages of nasal airways

1 They may be employed when oral airways are difficult or impossible to introduce

Disadvantages

1 They are easily kinked or pinched by anatomical distortions

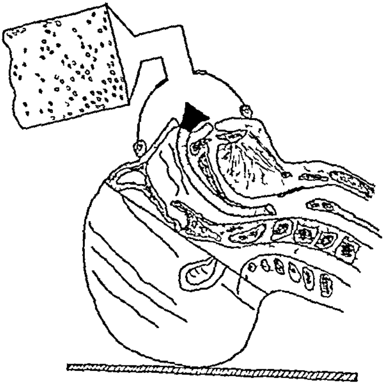


FIG 49 Nasal airway in place The airway must pass beyond the palate and support the tongue and other relaxed structures

2 They cause trauma to nasal mucous membranes which may be followed by epistaxis
3 The lumen of the tube may not provide an adequate airway for the total tidal volume of the patient

Procedure for insertion of nasopharyngeal airway

1 Select a catheter of suitable size The diameter should be slightly larger than the opening of the nostril
2 Insert the safety pin transversely through the nasal end
3 Lubricate the beveled end generously with petrolatum for a distance of approximately one inch
4 Insert the entire length of the tube into either nostril

Comment	*Reasons*
1 Do not force the catheter into the nostril	The use of force invariably results in trauma and epistaxis
2 Be positive that a satisfactory exchange is obtained	If catheters are too long and inserted too far, they may pass into the oesophagus and cause obstruction

Care of Airways

1 Cleanse airway by threading its lumen with a ribbon of moistened gauze attached to a wire If oily lubricant has been used, a second strip moistened with ether should be passed through it to remove it
2 Wash with soap and water and rinse thoroughly
3 Boil metal airways for 10 minutes Immerse rubber tubes in alcohol (70%) for 30 minutes
4 Rinse, dry, and thread with a dry gauze ribbon The ribbon may remain in place until airway is to be used

Tracheal Airways

Description Tracheal airways are tubes composed of rubber, silk, or flexible metal They pass into the trachea either through the oropharynx or nasopharynx and provide unimpeded pathways for respired gases When directly connected to inhalers or insufflators, the anesthetic gases are introduced into the trachea

Types Two types of tracheal airways are available oral and nasal (Fig 50)

1 *Oral* A variety of oral tubes is available All accomplish the same purpose
   a Anode This type is composed of latex rubber and has a metal spiral incorporated in its wall The spiral acts as a support and prevents kinking or collapse

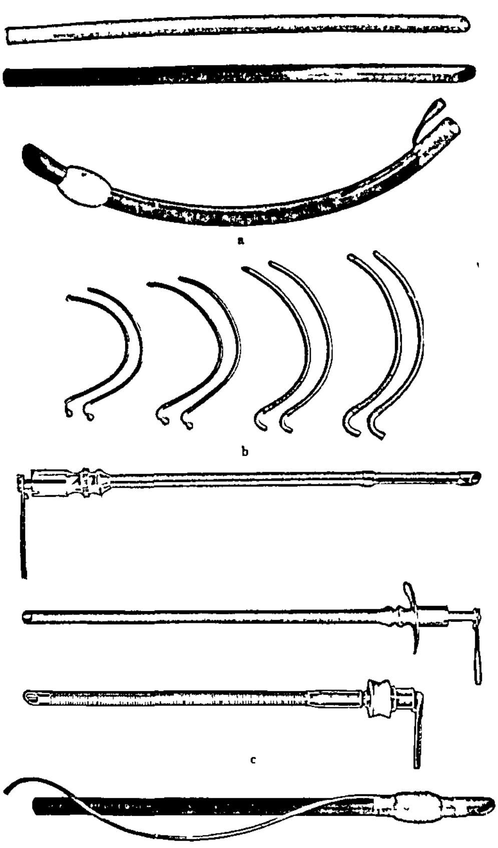


FIG 50 Orotracheal and nasotracheal airways (a) Latex or 'anode' tubes with metal spiral embedded in its wall (b) Plain rubber or Magill nasotracheal tubes (c) Metal (Woodbridge) tubes with stylet (d) Silk woven catheters (Courtesy of Richard Foregger Ph D)

b Plain rubber This type is made from soft rubber tubing possessing sufficient rigidity to prevent collapse under ordinary circumstances

c Silk This type is woven from silk and coated with plastic so that it is semi rigid and leak proof

d Metal This type (Woodbridge) is composed of flexible metal tubing possessing rigidity to prevent kinking The surface may be protected by a rubber dam sheath (penrose drain) to render it leak proof

2 *Nasal* Nasotracheal catheters are of one type (Magill) They are composed of soft thin walled rubber or plastic tubing with a smooth exterior and a beveled tracheal end (similar to nasopharyngeal tubes)

Characteristics of Tracheal Airways

1 *Shape Orotracheal* catheters are either straight or possess a slight curvature

Nasotracheal catheters usually possess a curvature of a circle whose radius is approximately 25–30 cms The catheter should be soft but sufficiently rigid to maintain the curved form

2 *Length* Catheters are usually supplied in lengths of 26–28 cms The distance the catheter is introduced varies for each individual The distance may be roughly estimated by placing the catheter along the anterior surface of the neck from the suprasternal notch to the tip of the chin

3 *Size* The bore of tracheal catheters is expressed in terms of "French" Sizes vary from 28 to 40F for adults and 18 to 30F for children The lumen should be as wide as possible but the wall should be as thin as permissible without risking danger of collapse

Diameter of catheters according to

Age	*Size*
0–1 yr	8–18 F
1–5 yr	15–24 F
6–15 yr	24–36 F
adults	28–40 F

Uses of Intratracheal Airways

1 For conduction of intratracheal anesthesia for operations about the head, neck, mouth, or pharynx

2 For a patient who is in the prone or other inaccessible position

3 For relieving respiratory obstructions which are not readily corrected by oropharyngeal or nasopharyngeal airways

4 For maintaining positive pressure for intrathoracic and other types of surgery in which positive pressure is required

5 For maintaining a patent airway in extremely obese patients or other subjects in whom this is accomplished with difficulty
6 For operations in which there is a possibility of aspiration of foreign particles or fluids (intestinal obstruction)
7 For upper abdominal or other types of surgery accompanied by reflex laryngeal spasm (Brewer-Luckhardt reflex)
8 For controlled and other methods of artificial respiration

Advantages of the Intratracheal Airway

1 It insures a completely patent and unobstructed airway when properly employed
2 It allows a seal to be secured between the catheter and the tracheal wall which prevents vomitus, secretions, or blood from passing into the respiratory tract
3 It allows the use of positive pressure when connected to a closed inhaler
4 It facilitates the aspiration of mucus, blood, and other secretions from the respiratory tract
5 It prevents or relieves laryngeal spasm

Disadvantages

1 The catheter acts as a foreign body in the respiratory tract and often causes irritation or initiates coughing or other reflexes
2 The lubricant necessary to facilitate the introduction of the catheter into the trachea may be undesirable
3 The wall of the catheter decreases the area of the tracheal lumen and causes partial obstruction, particularly in children and infants
4 Anesthesia of a deeper plane than is ordinarily required for the operation is necessary to obtund the cough reflex in the trachea (Second plane or deeper anesthesia is required to abolish the cough reflex in the trachea)
5 Trauma to the pharynx or larynx or injury to teeth and other structures may be caused while introducing catheters or during laryngoscopy
6 The bacterial flora from the nasopharynx is introduced into the trachea and bronchi, particularly if the nasal route is employed
7 The coughing or straining during light anesthesia causes increased venous pressure which may be detrimental to patients (Debilitated patients or patients having cardiovascular disease)
8 Anatomical distortions in nose or nasopharynx may cause obstruction of the catheter when the nasal route is employed
9 The dead space in mouth and pharynx is diminished Respiration simulating Cheynes Stokes may follow

Complications During Intubation

1 The catheter may become kinked pinched, or obstructed by secretions from the tracheobronchial tree
2 The catheter may be inadvertently introduced into the oesophagus instead of the trachea
3 The teeth, tongue, or mucous membranes may be injured by the laryngoscope, catheter, or stylet
4 The patient may bite upon the catheter if one does not insert a "bite block" before removing the laryngoscope
5 Apnea may follow insertion of the catheter from reflex coughing or bronchiospasm
6 The catheter may be inserted beyond the bifurcation of the trachea into a bronchus
7 Tracheitis, laryngitis, or pharyngitis may result from repeated attempts at intubation or if intubation is attempted during light anesthesia
8 Epistaxis may occur when the nasal route is employed
9 The catheter may slip out of the trachea during anesthesia if it is not held securely or is not anchored to face

INTRATRACHEAL ANESTHESIA

Definition Intratracheal anesthesia is inhalation anesthesia conducted when an intratracheal catheter is in situ

Techniques The subject is anesthetized with a major anesthetic agent by the open, semi closed, or closed technique Orotracheal or nasotracheal intubation is performed and the anesthesia is resumed and maintained in one of the following manners

1 The mask is replaced over the nose and mouth and the anesthesia is maintained by the open, semiopen, or closed technique The catheter merely acts as an airway
2 The catheter is connected to a semi-closed or closed inhaler and the gases are introduced directly into the trachea
3 A catheter connected to an insufflation apparatus is threaded into the lumen of the tracheal catheter and the anesthesia is continued by insufflation

Instruments Used for Intubation

Laryngoscope

Definition A laryngoscope is an endoscope employed for visualizing the larynx and trachea It consists of a *handle* to which is attached a *blade* for support of the tongue and epiglottis An electric light bulb located at the end is the source of illumination

Numerous types of laryngoscopes are available, but they may all be resolved into two main groups or types

Types *U Type* In this type the handle is parallel to the blade and may be

held either horizontally or vertically (Jackson) This type is less frequently employed for anesthesia

L Type The handle is at right angles to the blade and may be held vertically (Flagg, Guedel) This type is the most popular for anesthesia (Fig 51)

MacIntosh—oropharyngoscope This consists of a curved tongue blade attached to a handle containing a battery A bulb at the beak illuminates

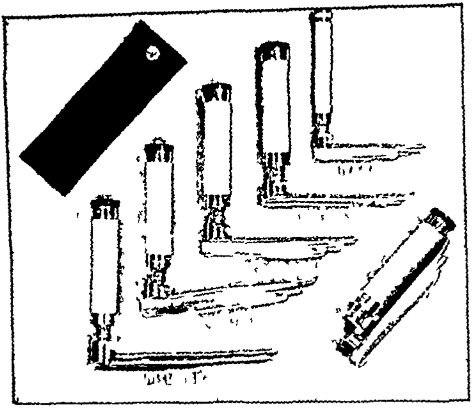


Fig 51 The (L) type of laryngoscope commonly employed for intratracheal anesthesia The blade and beak have been modified to suit the needs of various clinicians (Courtesy of Richard Foregger Ph D)

the hypopharynx The blade supports the tongue and exposes the larynx without touching the epiglottis (Fig 52)

Sizes Most laryngoscopes for anesthesia (L type) are provided with interchangeable blades of different sizes One is for infants, one is for children, and one for adults

Features

1 The handle is cylindrical in shape and contains a low voltage battery as a source of electric current for the bulb A rheostat may be present at the end of the handle to vary the intensity of the light
2 The blade is sturdy, detachable and has the following features
   a It is provided with a semi circular groove whose concavity faces the right This groove acts as a path for visualizing the larynx
   b It has a beak at its end for lifting the epiglottis

Stylets

Definition Stylets are rods composed of semi flexible metal or plastic which fit into the lumen of soft intratracheal catheters and provide them with body and rigidity (Fig 53)

Features Stylets should have the following features

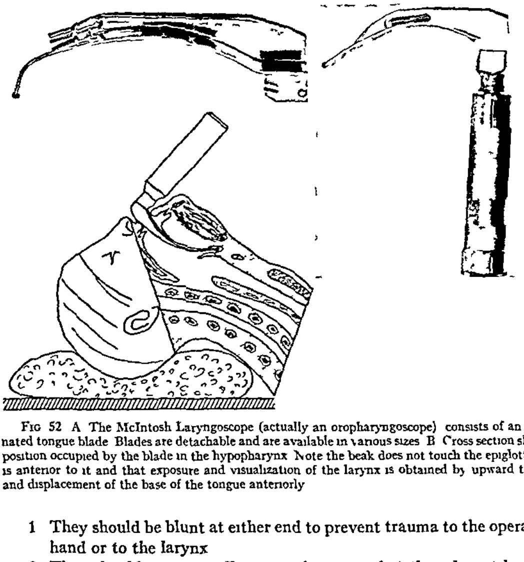


Fig 52 A The McIntosh Laryngoscope (actually an oropharyngoscope) consists of an illuminated tongue blade Blades are detachable and are available in various sizes B Cross section showing position occupied by the blade in the hypopharynx Note the beak does not touch the epiglottis but is anterior to it and that exposure and visualization of the larynx is obtained by upward traction and displacement of the base of the tongue anteriorly

1 They should be blunt at either end to prevent trauma to the operator's hand or to the larynx
2 They should possess sufficient resilience so that they do not bend or buckle
3 They should be provided with a stop which fits over the end of the catheter and slides up and down to vary the length of the part of the stylet which fits into the catheter (usually a cork is employed)

Slip Joints

Definition Slip joints are short lengths of metal, hard rubber, or plastic tubing employed to connect intratracheal catheters to inhalers

Types *Funnel type* Usually employed for nasal airways when the open technique of anesthesia is used (Fig 49)

Elbow type Usually employed for nasal airways when the closed technique is used (Fig 60)

Straight sleeve type Employed for oral or nasal catheters when the closed system is used (Fig 53)

Features Slip joints should have the following features

1 They should have a bore as wide as that of the catheter to which they are attached

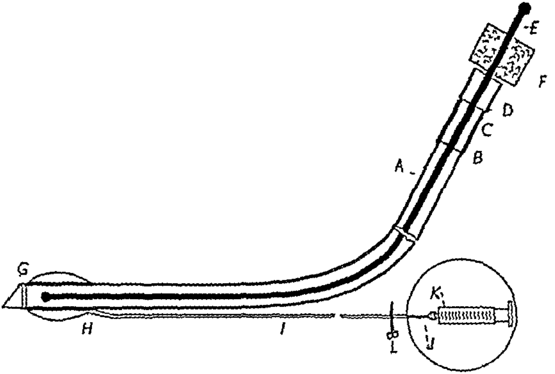


FIG 53 Schematic diagram of a closed oral intratracheal assembly The (A) latex catheter has a wire spiral embedded in its wall to prevent kinking and collapse The spiral ends at (B) so that section (C) of the catheter may accommodate the (D) metal slip joint Note that the slip joint is introduced as far as the spiral otherwise kinking occurs at this point Note that the internal diameter of the slip joint is the same as that of the catheter The (E) stylet composed of stout semirigid metal is knobbed at either end and fitted with a (F) rubber stopper guard The end of the stylet rests several centimeters from the (G) beveled silk woven tip (H) The inflatable cuff composed of thin latex rubber is provided with (I) a small catheter attached to a (K) 10 cc syringe fitted with a (J) short needle (L) A clamp is used to pinch catheter when the cuff is inflated

2 They should slip in and out of adapters easily

3 They should form a leakproof union with adapters

Cuffs

Definition Cuffs are balloons composed of latex rubber designed to encircle orotracheal catheters at the tracheal end When inflated with air, they produce a seal between the tracheal wall and the catheter (Fig 53)

Features Cuffs possess the following features

1 They are one to two inches in length

2 They are connected to a long thin catheter which is used to inflate them with air
3 They encircle the catheter snugly or are built in the wall

Insertion of Orotracheal Airways

Description Under deep anesthesia the larynx is exposed by means of a laryngoscope A catheter of suitable size is then inserted into the trachea

Types

1 *Open oral* In these intubations no seal exists between the catheter and the tracheal wall The mask is replaced after the tube is introduced

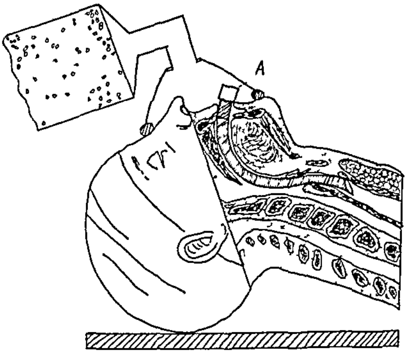


FIG 54 Intratracheal anesthesia by the open oral technique is accomplished by introducing an orotracheal catheter by means of direct laryngoscopy replacing the inhaler and resuming anesthesia in the usual manner No cuff is necessary The catheter is secured by strapping the (A) metal adapter to the face with adhesive The circle filter the semi-closed inhaler, open masks or insufflation technique may likewise be employed instead of the to and fro inhaler as shown above

Open masks, insufflators, semi closed or closed inhalers may be employed to maintain the anesthesia (Fig 54)

2 *Closed oral* In these intubations, the catheter fits snugly into the trachea, is sealed by an inflatable cuff, which fits between the tube and the tracheal wall, or is sealed off from the pharynx by packing with strips of gauze It is then connected to a closed rebreathing system for maintenance of anesthesia (Fig 55)

Material

1 Three tracheal catheters One is of the size judged necessary for the patient, one is smaller and one is larger

2 A semi rigid stylet This gives rigidity and body to soft flexible catheters (Fig 53)
3 Petrolatum (vaseline) or similar lubricant for the stylet and catheter
4 A suction apparatus equipped with a metal curved tip
5 Urinary catheter which easily passes into the tracheal catheter This should be fitted to a glass connecting tip for attachment to the suction tubing
6 A pillow, approximately 3" thick, to elevate the head

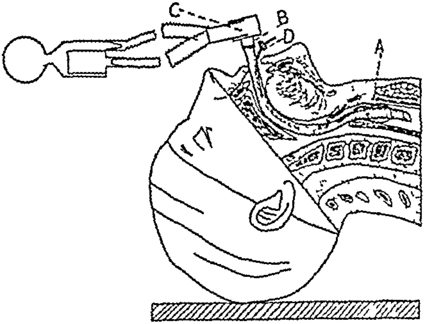


FIG 55 Orotracheal airway connected to a closed inhaler (A) The inflatable cuff allows a seal between the tracheal wall and the catheter so that a completely closed system is secured (B) A slip joint connects the catheter to the (C) metal sleeve (D) The catheter and the pinch cock communicate with the cuff The diagram depicts a circle filter However a to and fro inhaler may be used equally well

7 Adhesive cut in strips 5/8"×8" This is necessary to anchor the catheter to the skin of the face
8 Two gauze packs 2"×12" with rings for packing pharynx, or an inflatable rubber cuff for each catheter (Fig 53)
9 Gauze pad to protect teeth, or a strip of adhesive 1"×1½" folded in two, lengthwise
10 A mouth prop (bite block) This may be made by wrapping a strip of adhesive around a partly-used roller bandage (approximately 5/8"×2")
11 One pinch clamp or small artery forceps to pinch the tube leading to the cuff if a cuff is employed
12 One 10 cc syringe to inflate the cuff if a cuff is employed

Preparation of Materials

1 Arrange an instrument stand or tray on the righthand side of the

Reasons

The "setup" should be on the right side because the right hand re-

operating table so that it is within ready reach of the anesthetist	mains free for picking up instruments and other manipulations
2 Spread the tray with a sterile towel and place equipment, all sterilized, upon it	All objects which pass into the pharynx or trachea should be sterilized
3 Lubricate the end of the catheter with sterile vaseline on a sterile sponge for a distance of 3″ to 4″	If the entire catheter is lubricated, it is difficult to handle and hold during manipulations
4 Bend the stylet to form a curve whose radius is approximately 28″ and lubricate generously the entire length of the stylet with vaseline	It will be difficult to withdraw the stylet from the catheter if it is not well lubricated
5 Adjust stylet into the catheter so that the tip rests approximately 1/2″ from its end (Fig 53)	If the end of the stylet protrudes from the catheter, it may cause trauma to the vocal cords
6 Moisten packs, if they are employed, with physiological saline or liquid petrolatum and express excess liquid	Dry packs may cause irritation to mucous membranes of the pharynx
7 Ascertain that the laryngoscope is correctly assembled, and that the battery and light are in working order	The laryngoscope may become disassembled during manipulation if not properly put together

Procedure	*Reasons*
1 Deeply anesthetize the patient with a major anesthetic drug, such as ether, cyclopropane, or chloroform (see page 100)	Complete relaxation of muscles of neck with flaccidity of the jaw and abolition of pharyngeal reflex are necessary for successful intubation
2 As soon as the patient is relaxed, place the pillow under the occiput so that it rests under the shoulders for a short distance Arrange the head so that it is in the midline of the long axis of the body (Fig 57)	The pillow elevates the head to the proper angle and causes relaxation of the anterior muscles of the neck (Fig 56)
3 Extend the head by applying traction to the lower jaw so that the chin points directly towards ceiling	Traction stretches the structures of the neck and elevates the trachea and epiglottis
4 Induce an apnea by hyperventilation by manually compressing and relaxing the breathing bag for approximately thirty seconds	The apnea results from removal of carbon dioxide The patient does not breathe and become "light" during intubation
5 Close obturator, remove the mask	Loss of mixture from inhaler

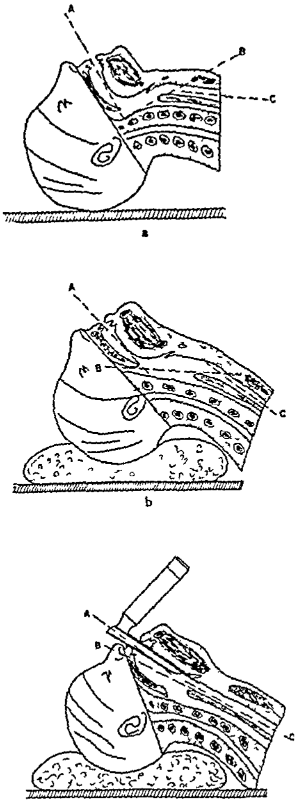
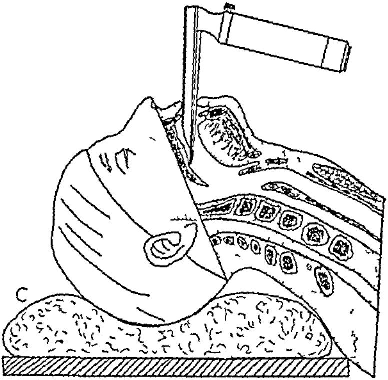


FIG 56 The effects of elevating and hyperextending the head upon the improving the exposure of the larynx for endotracheal intubation A The relationship of the axes of the mouth, hypopharynx and trachea to each other under ordinary circumstances with the supine position with head unsupported B Elevation and hyperextension bring all three axes into an almost straight line C The forward traction upon and elevation of the structures in pharynx further hyperextend the head and bring all three axes into line so that the larynx may be fully exposed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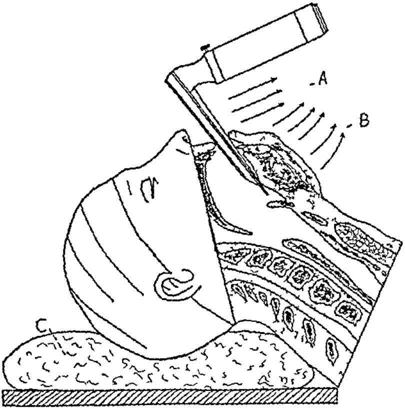
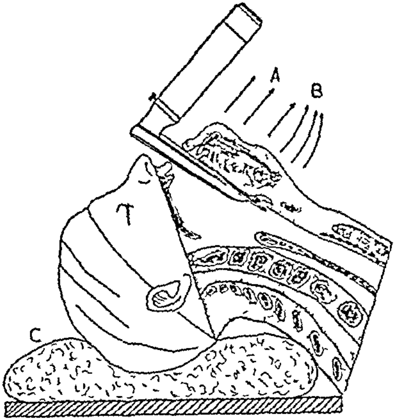

A
B
C



c

Fig 57 Cross section showing introduction of the laryngoscope in performing laryngoscopy Note the head is elevated by (C) a pillow

(a) The blade is first introduced in a vertical manner at the right side of the mouth until the palate and posterior pharyngeal wall are visualized

(b) The blade is rotated towards a horizontal position until the epiglottis is visualized. All force should be applied in the direction of the (A) and (B) arrows

(c) The blade is introduced so that the beak elevates the epiglottis and pushes it up against the base of the tongue Note that a lifting force is exerted upward (A) during laryngoscopy and the blade is away from the upper incisor teeth.

from face, and withdraw pharyngeal airway	should be prevented to facilitate reanesthetization
6 Apply gauze protector to the upper incisor teeth	Roughening or other damage from the laryngoscope occurs more frequently to the upper teeth
7 Grasp the lighted laryngoscope in the left hand Place the thumb into the right side of mouth and displace lower jaw forward	The right hand remains free for insertion of catheter and other manipulations
8 Insert the beak of the blade of laryngoscope into the right side of mouth at its angle Gradually introduce it into the pharynx and, at the same time, displace the tongue as far to the left of the mouth as possible (Fig 57)	The space to the right of the laryngoscope (the side to which the groove opens) is cleared and should remain free for passage of the tracheal catheter

9	Gradually rotate the blade from a vertical to a horizontal position until the right anterior pillar is visualized Then swing blade toward midline of the mouth	The blade of the laryngoscope follows the curvature of the palate
10	Hook right index finger over the upper teeth to make traction in a cephalad direction At same time displace lower jaw with blade of the laryngoscope in a caudad direction (Fig 57)	This maneuver allows the mouth to be opened widely The blade of the laryngoscope is inserted so that pressure is avoided on the upper incisors
11	Rotate blade more horizontally and continue to exert force on the lower jaw This force should be a lifting of the handle in a direction toward the ceiling (Fig 57)	A rotary force using the incisor teeth as a fulcrum for the laryngoscope should be avoided (Fig 58)
12	As soon as the epiglottis is exposed, insert the beak of the blade beneath it and continue to lift upward on the handle of the laryngoscope, extending the head still more, if necessary The larynx will then be seen	The larynx is beneath and beyond the epiglottis and can only be visualized by lifting the epiglottis upward with the beak of the blade
13	When the larynx is visible, determine the size of the catheter necessary for the patient (see table)	If catheter is too large, spasms and trauma follow its attempted passage A small one causes leakage or a partial obstruction to the airway if the closed system (cuff) is employed
14	Quickly remove secretions from the pharynx by suctioning	Remove secretions so that they will not pass into trachea and cause obstruction
15	Grasp the stylet, together with the catheter, at its slip joint and hold them both in the right hand	The stylet must be held so that it does not slide in or out of the catheter
16	Introduce the catheter into the mouth and pharynx along right side of laryngoscope blade and insert it a distance of 2–3 cms into the trachea beyond the vocal cords Groove of blade must remain free for visualization of the intubation	Long catheters may be introduced beyond the bifurcation of the trachea into a bronchus, particularly the right bronchus, if care is not exercised
17	Partly withdraw laryngoscope but allow it to remain in mouth in vertical position to act as a "bite block"	If patient becomes "light" during the intubation, he may bite down on catheter, unless some protection remains between teeth

18 Withdraw stylet, holding catheter with left hand, place bite block between teeth, and remove laryngoscope	Patient may become "light" during intubation Anesthesia should be resumed as soon as possible
19 Connect the catheter to the inhaler if the closed orotracheal technique is employed or replace the mask if open orotracheal technique is contemplated	The catheter merely replaces the oropharyngeal airway in the open oral method
20 If secretions are present, remove these by using the suction Then pack pharynx or inflate cuff if one is employed (Fig 55)	This secures a seal which prevents a leak and loss of mixture around catheter
21 Anchor catheter to the face with several strips of adhesive	This prevents the catheter from slipping further into the trachea or from being accidentally jerked out of the mouth or nose

Advantages of Orotracheal Airway

1 Semi rigid tubes or catheters may be employed to minimize the danger of compression or kinking
2 Visualization of the larynx allows selection of catheters of proper bore and length and insures precision and elimination of guesswork in inserting the catheters
3 It allows the use of a closed system with cuffs or packs

Disadvantages

1 Deep anesthesia is required for exposure of the larynx
2 The possibility of causing trauma to the pharynx and trachea is ever present

Comment	*Reasons*
1 Do not "rush" intubation The patient must be deeply anesthetized (3rd plane of stage III) and completely relaxed before attempting intubation	Patient becomes "light" during intubation due to inhalation of room air Attempts at intubation during light anesthesia cause coughing, vagal reflexes, increased venous pressure, and other circulatory disturbances
2 Always hold the catheter in the left hand at its point of emergence from the mouth during maintenance of anesthesia	This avoids having catheter slip out of the larynx if head is suddenly moved by the operator
3 Observe thorax closely for asymetrical respiratory move	Catheter may be in the right bronchus, thus occluding the left

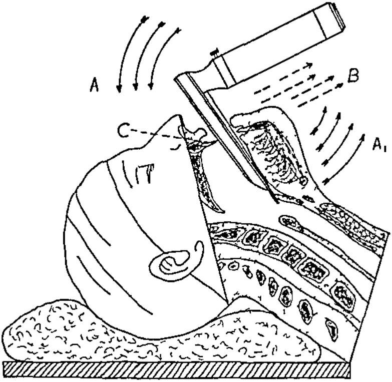


FIG 58 Improper technique during laryngoscopy results in trauma If a rotary force (A) and (A_1) is used to lift the epiglottis instead of (B) the (C) upper incisor teeth act as a fulcrum and are dislodged loosened or chipped

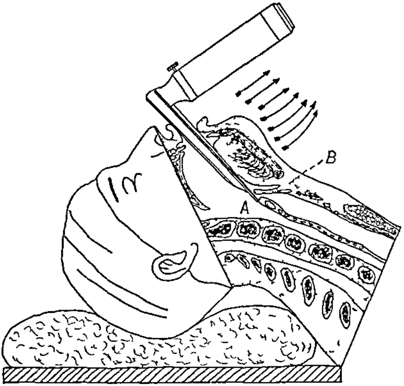


FIG 59 The laryngoscope rests in the (A) esophagus causing obstruction of the (B) larynx This may result from poor relaxation introducing the blade too far anatomical distortions or failure to lift upward with the laryngoscope

ments, dyspnea, or labored respiration Be positive that the respiratory effort is in proportion to the tidal exchange	one The right bronchus is more easily catheterized than the left because of its length and position
4 Do not insert the laryngoscope too far into the pharynx If larynx is not visualized, withdraw it partly until epiglottis is seen	The beak of the blade may be passed beyond the larynx into the esophagus if the blade is long or the larynx is ventrally placed (Fig 59)
5 Do not tilt the blade of laryngoscope in such a manner that the incisor teeth act as a fulcrum (Fig 58)	The force exerted may break, chip, or dislodge the teeth
6 Hold the tongue against the floor of the mouth with the left thumb when packing pharynx with gauze	This prevents the tongue from rolling back which might cause the frenulum to become torn
7 Introduce a well lubricated urinary catheter attached to a suction apparatus and remove any secretions which accumulate in the catheter	Secretions cause obstruction to respiration
8 Inspect teeth before performing intubation	Loose teeth or removable dental work should be removed or protected
9 Remember that attempts to save two or three minutes may result in the loss of fifteen	Intubation is unsuccessful if the patient is not properly anesthetized
10 Be certain that the cuff is just below the vocal cords and not too far into the trachea	This prevents accumulation of excessive amounts of fluid above cuff which would be aspirated when cuff is deflated

Insertion of Nasotracheal Airways

Description The patient is anesthetized and a curved soft rubber catheter of suitable size is passed through either nostril into the larynx The intubation is accomplished either by laryngoscopy or by the "blind" technique

Types

1 *Open nasal* In these intubations the catheter fits loosely in the trachea and no pack or cuff is employed The mask is usually replaced after intubation and the anesthesia is continued in the usual manner

2 *Closed nasal* In these intubations, a seal is secured by a pack or snug fit existing between the catheter and the tracheal wall (large catheter) Anesthesia is continued by means of a closed or semi closed inhaler connected directly to the catheter (Fig 60)

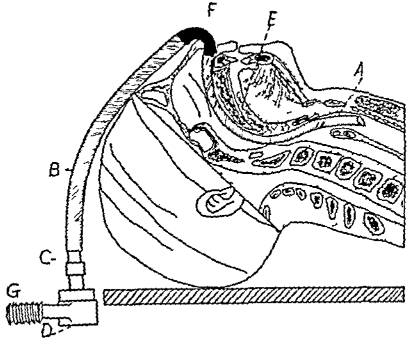


Fig 60 (A) Closed nasotracheal airway connected to (G) the closed inhaler by means of (F) a metal elbow fitted to a (B) non collapsible tube and (C) a sleeve and (D) a slip joint (E) A gauze pack minimizes leakage of gases and absorbs secretions

Materials

1 An assortment of tracheal (Magill) catheters Prepare one which is larger and one which is smaller than the size necessary for the patient (see page 166 for sizes, Fig 50)
2 Vaseline (sterile) or similar lubricant for the catheter
3 Suction equipped with a metal curved tip and a catheter which easily slides into the tracheal catheter
4 Laryngoscope of Guedel, Flagg, or similar design
5 Slip joints for the catheters and the adapter for the inhaler
6 Pillow approximately three inches in thickness to elevate the head
7 Adhesive strips 5/8″ × 8″ for anchoring catheter to the face
8 Two gauze packs 2″ by 12″, moistened with saline or liquid petrolatum
9 Gauze strip or square of adhesive folded lengthwise to protect teeth
10 Intubation forceps for guiding the catheter into the larynx (Fig 61)

Fig 61 Forceps for introducing nasotracheal airway into the trachea under direct vision (Courtesy of Richard Foregger Ph D)

Preparation of Materials Follow directions given for insertion of orotracheal airways

Procedure

1 Anesthetize the patient, arrange head, pillow, etc, in the manner described for the insertion of orotracheal airways
2 Examine each nostril and select the one without obstruction or deformities
3 Extend and hold chin with left hand as for orotracheal intubations
4 Grasp the catheter at its nasal end between thumb and index finger of the right hand Allow the catheter to maintain its natural curve and hold it with the concavity upward
5 Insert the catheter gently into the nostril and gradually thread it into the nasopharynx Do not exert any force whatsoever while introducing it
6 As soon as exhaled and inhaled gases pass through the catheter listen (with ear close to inlet of catheter) for the point of maximum intensity of respiration
7 Halt its advance and at the point of maximum inspiration slip it into the trachea with a thrust
8 Anchor catheter securely with adhesive and pack pharynx
9 Connect the catheter to the inhaler or resume anesthesia by replacing the mask and using the catheter as an airway

Signs of a Successful Intubation

1 A sharp expulsive cough occurs which is followed by a change in quality of respiratory sounds to a lower pitch (under light anesthesia)
2 The thorax is easily inflated by cautious mouth to tube insufflation, otherwise a gurgling sound and bulging at epigastrium occurs
3 Air returns through the catheter from the thoracic deflation when mouth to tube insufflation is practiced The odor of the anesthetic drug employed is recognized if the catheter is in the trachea
4 The breathing bag moves when the inhaler is connected and the thorax may be inflated when breathing bag is compressed

Failures in "Blind" Intubations

1 The catheter strikes the anterior commissure of the larynx (Fig 62a)

   Causes

   a Hyperextension of the head
   b Too great a curvature of the catheter

   Signs

   a A feeling of resistance as the catheter is guided inward

b A whistling sound accompanying each phase of respiration
Correct this by flexing head, using a different catheter, or by guiding catheter into the larynx under direct vision

2 The catheter enters the esophagus (Fig 62b)

Causes

a The catheter is too soft or does not possess sufficient curvature
b The head is flexed too sharply

Signs

a Disappearance of breath sounds as the catheter is advanced inward

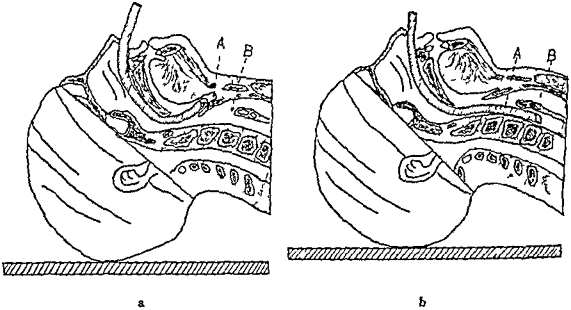


FIG 62 (a) Nasotracheal airway improperly placed in (A) the anterior commissure instead of the (B) trachea (b) Nasotracheal airway improperly placed in (A) the esophagus instead of (B) the treachea

after a point of maximum intensity is reached
b A sucking sound with respiration due to movements of the esophagus with each phase of the respiration
Correct this by partially withdrawing the catheter, extending the head, and attempting it once again, or by changing the catheter

3 Lateral displacement into right or left pyriform fossa

Causes

a Abnormalities of the nasal septum or turbinates

Signs

a *A feeling of resistance as the catheter is inserted into the nostril*
b The catheter may cause a bulge, or it may be felt passing laterally by the hand placed on outside of neck
c Breath sounds disappear as the catheter is advanced
Correct this by withdrawing the catheter and rotating it slightly in the

opposite direction The point of the catheter rotates in the pharynx if the end is rotated The thyroid cartilage may also be manipulated laterally to fit and guide catheter into the larynx

Advantages of Nasotracheal Intubations

1 The catheter may be introduced into the trachea without the aid of a laryngoscope
2 The intubation may be accomplished either under light or deep anesthesia
3 The technique may be employed when the mouth cannot be opened for oral surgery, or in circumstances in which the orotracheal route is not feasible, or when it has been attempted without success

Disadvantages

1 A completely closed system cannot be easily secured
2 The proper size of the catheter is difficult to determine
3 Trauma to the mucous membranes frequently causes epistaxis, pharyngitis, and laryngitis
4 Bacterial flora of the nose is introduced into the trachea
5 Spurs and other abnormalities in the nasopharynx may cause pinching and obstruction of the catheter
6 The catheter may become kinked in the pharynx or compressed by tight packing or flexion of the head, particularly in the prone position
7 Suction catheters are not readily introduced into its lumen
8 Intubation is not easily accomplished if respiratory movements are depressed

Comment	*Reasons*
1 Do not exert force if resistance is felt during introduction of the catheter Attempt passage in the other nostril	Adenoid tissue, spurs, and deformities may be present and cause trauma and epistaxis
2 Always pack the pharynx with gauze if the catheter is connected to a closed inhaler	The pack acts as a seal and prevents loss of gases It also absorbs blood and secretions in oropharyngeal surgery
3 Select as large a catheter as possible without risking injury to nares, pharynx, or larynx	Small catheters cause partial obstruction to respiration
4 Always be positive that the tidal exchange is proportional to the respiratory effort	Partial obstruction may be present due to distortion or compression of the catheter
5 Do not attempt to force the	The catheter will kink and bend

catheter into the larynx if spasm is present	upon itself Wait until spasm "breaks"
6 Do not use any slip joint or connecting piece which has a diameter less than the catheter	Narrow orifices cause obstruction to respiration
7 Compress the opposite nostril with the free hand when listening for breath sounds	This avoids confusion with the sound of respiration through it
8 Do not attempt intubation with soft flaccid catheters which have lost their curvature and resilience	Best results are obtained when the catheter employed is resilient and possesses a curvature conforming to the curvature of the nasopharyngeal fossa
9 Use funnel shaped slip joints for open nasal intratracheal anesthesia	They prevent the catheter from slipping into the nose
10 Intubation forceps should be employed merely to guide the catheter into the larynx	Trauma to the larynx results if the forceps is introduced beyond the vestibule

Nasotracheal Intubation by Direct Vision

If after several attempts, the catheter does not slip into the trachea, expose

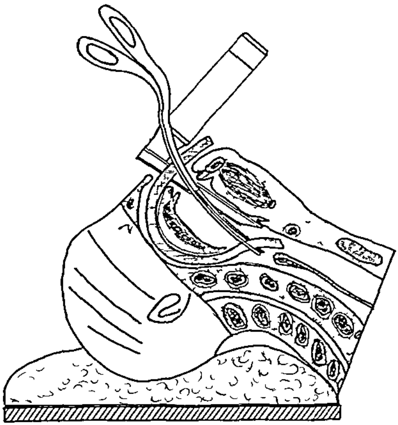


FIG 63 Introducing nasopharyngeal airway by direct vision using the intubation forceps

the larynx with the laryngoscope and introduce it with intubating forceps in the following manner

1 Reanesthetize the patient if he is not sufficiently relaxed
2 Inject succinylcholine or other muscle relaxant
3 Expose larynx as described for orotracheal intubation
4 Advance the catheter gently into pharynx almost up to the larynx so that it rests in the midline
5 Insert the forceps along the side of the groove of the laryngoscope on the right side
6 Grasp the catheter with the forceps approximately one inch from the beveled end, place it in the vestibule of the larynx, and guide it inward (Fig 63)
7 Withdraw forceps and laryngoscope
8 Flex head on thorax and gently thrust catheter inward still further to insure freedom from kinking or obstruction

Anesthetic Agents for Intratracheal Anesthesia

The anesthetic agent employed must produce relaxation of the neck muscles, flaccidity of the jaw, and abolition of the pharyngeal and laryngeal reflexes if intubation is to be successful The utility of the various anesthetic agents may be summarized as follows

	Utility	*Advantages*	*Disadvantages*
1 *Ether*	Most satisfactory and reliable Recommended for beginners	1 Glottis is relaxed Cough reflex is abolished 2 It is a respiratory stimulant 3 It produces excellent relaxation 4 Anesthesia lasts longer than with other agents, allowing sufficient time for intubation	1 Induction may be prolonged and often difficult
2 *Cyclopropane*	Very satisfactory but requires experience at induction and intubation	1 Induction is rapid, relatively simple and pleasant 2 Relaxation is satisfactory	1 Recovery occurs quickly during intubation 2 Laryngeal spasm is frequent or easily provoked 3 Respiration is quiet
3 *Chloroform*	Satisfactory but not recommended because of cardiac effects	1 Relaxation of neck and jaw muscles is excellent 2 Cough reflex is abolished 3 Glottis is relaxed 4 Induction is pleasant 5 Duration of anesthesia allows sufficient time for intubation	1 It is a circulatory depressant 2 The possibility of toxic hepatitis is always present 3 The margin of safety is narrow—danger of over dosage
4 *Vinyl Ether*	Not satisfactory	None, except that induction is rapid	1 Relaxation of muscles of neck and jaws is not satisfactory

	Utility	*Advantages*	*Disadvantages*
			2 Anesthesia is evanescent and does not allow time for intubation
5 *Ethyl Chloride*	Not satisfactory	None, except that induction is rapid	1 Relaxation of muscles of neck and jaws is not satisfactory 2 Anesthesia is evanescent and does not allow time for intubation 3 It is a circulatory depressant
6 *Nitrous Oxide or Ethylene*	Not satisfactory unless administered with basal narcosis or heavy doses of premedication and in conjunction with topical anesthesia to the pharynx and larynx and with a muscle relaxant	None, except that the induction period is short	1 Intubation is difficult to perform without trauma 2 It does not abolish cough reflex or relax muscles of neck or jaw 3 Rapid recovery does not allow time for intubation
7 *Ultra short acting Barbiturates* (Pentothal or Evipal or Surital)	Not satisfactory alone (Spray nasopharynx and larynx with 4% cocaine prior to induction) and use muscle relaxant	None except that induction is simple and rapid	1 Cough reflex is increased Spasm of larynx is common 2 Muscular relaxation is obtained with difficulty in robust subjects 3 Respiration is depressed
8 *Avertin*	Not satisfactory unless supplemented with gases or ether and muscle relaxant	None when used alone	1 It depresses respiration 2 It does not completely abolish the laryngeal and pharyngeal reflexes 3 It does not yield satisfactory relaxation of muscles of neck and jaws
9 *Topical*	Suitable for patients with obstructive symptoms or for whom mask is difficult to apply	Avoids obstruction	1 Unpleasant to patient 2 Relaxation secured with difficulty in non cooperative patients 3 Gagging common

Technical Complications During Intratracheal Anesthesia

1 *Absence of respiratory movements*

Cause	*Symptoms*	*Treatment*
a Overdosage	a Signs of 4th plane or 4th stage anesthesia are present. b The thorax is easily inflated when the breathing bag is compressed	Deflate the breathing bag fill with oxygen and perform artificial respiration
b Obstruction	a The thorax is not readily inflated when the breathing bag is pressed b The respiratory effort is not in proportion to the tidal exchange (if partial)	Locate cause (see below)
c Acarbia or hypocapnia	a This usually follows hyperventilation b The thorax is easily inflated and deflated	Allow apnea to persist until respiratory movements are resumed

Cause	*Symptoms*	*Treatment*
d Reflex apnea due to excessive positive pressure or presence of the tube	a. Breathing bag is over-distended. b Signs of upper third stage anesthesia are usually apparent.	Deflate bag
e Light anesthesia	a Spasmodic expiratory efforts due to active cough reflex are present. b Jaws are rigid. c Swallowing movements are present.	a Increase proportions of anesthetic agent. b Gently increase the pressure by compressing the bag
f Overdose of muscle relaxant	a Apnea	a Artifical respiration

2 Respiratory movements of the thorax are unimpeded but movements of the breathing bag are absent

a. Catheter is in the esophagus instead of the trachea.	a Expired gases pass through nose and mouth none through the catheter	a Reanesthetize and replace catheter properly
b The obturator is closed	a The breathing bag cannot be compressed b No respiratory sounds are heard in the vicinity of the face. c. The anesthesia becomes lighter	a Open obturator and deepen the anesthesia.
c. The slip joint has become disconnected from the inhaler	a Respiratory sounds become audible about the mouth. b Breathing bag may deflate quickly	a Replace and reanesthetize the patient.

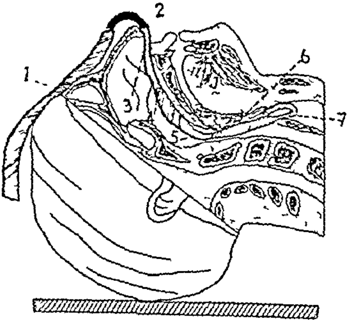


FIG 64 Possible sites of obstruction in nasotracheal airway
(1) Collapse of the extension tube
(2) Undersized slip joints.
(3) Kink at the slip joint.
(4) Compression in the nasopharynx from anatomical [illegible]
(5) Obstruction by secretions in the lumen.
(6) Compression from packs.
(7) Tube bent upon itself.

3 *The breathing bag deflates rapidly, respiratory movements are unimpeded but shallow*

Cause	*Symptoms*	*Treatment*
a The cuff is deflated or packs are ineffective b The catheter is pulled out of trachea	a Gas escapes from mouth and nose when bag is compressed	a Reinflate the cuff or repack the pharynx
c Presence of bronchopleural fistula or perforation in the trachea	b The bag is deflated when the bag is compressed, but no gas escapes from the inhaler or the nose and mouth	b Plug the fistula with sterile gauze if possible to minimize the leak
4 *Bag becomes distended though flowmeters are functioning properly*		
a A small catheter in a large trachea allows air to be drawn in around the vocal cords as they relax during inspiration The air is forced into the inhaler as they become adducted during expiration	a This occurs in open oral or nasal technique b It usually occurs during light anesthesia c Bag fills during expiration Movement of bag is greater at expiration than at inspiration	a Replace the mask over face until patient is anesthetized Pack pharynx or inflate cuff if closed technique is contemplated

Causes of Obstruction During Intratracheal Anesthesia

1 The catheter is kinked at its slip joint, or in the nose mouth or larynx Connecting tube from the slip joint to the adapter may be kinked	a A decreased volume of respired gases passes through the catheter b The respiratory effort is out of proportion to the tidal exchange c Signs of anoxemia or asphyxia such as cyanosis dilated pupils hypertension etc are present	a Relieve the obstruction in the airway
2 Patient bites on catheter because the anesthesia is light and mouth prop is faulty or the prop has inadvertently slipped out of the mouth	a Respired gases pass through the mouth and nose along the outside of the tube if it is of a smaller bore than the trachea	a Replace the mouth prop if jaws can be pried apart Otherwise withdraw the catheter

Anesthesia Techniques for Intubation

Intubation with Pentothal and Muscle Relaxant

Procedure

1 Spray nose, pharynx or larynx with a desired local anesthetic solution
2 Administer pentothal or other ultrashort acting intravenous anesthetic until patient is narcotized
3 Inject 20–40 mgm succinyl choline or equivalent dose of other muscle relaxant intravenously
4 *Introduce laryngoscope, expose larynx and pass catheter*
5 Connect tube to semi closed apparatus and proceed with nitrous oxide or to closed apparatus and proceed with cyclopropane or other desired agent

Intubation with Pentothal Cyclopropane and a Muscle Relaxant

Procedure

1 Spray nose, pharynx or larynx with local anesthetic solution (optional)

2. Administer pentothal or other ultra short acting drug until basal narcosis is obtained
3. Administer cyclopropane until patient is in 3rd plane
3. Administer 20–40 mgm succinyl choline or other muscle relaxant intravenously
5. Hyperventilate, expose larynx, and intubate
6. Connect apparatus and continue with cyclopropane or cyclopropane ether

Intubation with Pentothal Nitrous Oxide Ether and a Muscle Relaxor

1. Spray nose pharynx and larynx with local anesthetic solution (optional)
2. Induce basal narcosis with pentothal, or other ultra short acting barbiturate
3. Commence nitrous oxide as described under section on nitrous oxide
4. Gradually add ether until plane 2 or 3 is reached
5. Add 20–40 mgm succinyl choline or other muscle relaxant intravenously
6. Expose larynx and intubate
7. Connect to closed system
8. Maintain with oxygen ether

Technique Using Indirect Laryngoscopy

Materials

1. Nasal spray
2. Cocaine 10% and 4%
3. Jackson pledget holders (Pilling introducers)
4. Mirror for indirect laryngoscopy
5. Head mirror or head lamp
6. Nasopharyngeal syringe with long curved nozzle

Procedure

1. Anesthetize nose palate tongue and oropharynx by spraying with 4% cocaine
2. Wrap pledget of cotton on Pilling introducer soak with 10% cocaine and press dry
3. Warm mirror and visualize each pyriform fossa Spray each with 4% cocaine
4. Introduce cotton pledget in each pyriform fossa and hold in contact for 5 minutes
5. Remove, pledget holders and expose larynx
6. Introduce 2 cc 4% cocaine with syringe equipped with long curved nozzle into larynx
7. Introduce intratracheal tube using curved stylet

Transtracheal Anesthesia

Definition Topical anesthesia of the larynx, trachea and bronchi obtained by injecting a local anesthetic solution into the trachea through the thyrocricoid membrane

Anatomy The thyrocricoid membrane may be identified by a dense triangular area of connective tissue between the thyroid and cricoid cartilages This area may be pierced with a fine needle

Materials

a 2 cc syringe
b 4% cocaine, 2% pontocaine, or other topical anesthetic
c 23 gauge 1½ inch long needle

Technique

1 Position Place the patient in the supine position with the head hyperextended
2 Palpate the cricoid membrane between the thyroid (A, Fig 65) and the cricoid (B) cartilages with the left forefinger
3 Cleanse the skin over the trachea and apply a sterilizer
4 Raise a wheal over the criocid membrane and introduce the needle with syringe attached containing solution in the midline (C, Fig 65)
5 Advance needle perpendicular to the skin until lack of resistance is felt, at which time the point is within the trachea
6 Instruct patient not to cough, swallow or talk
7 Aspirate air to ascertain if the needle is in the trachea
8 Quickly inject 2 cc of solution and withdraw the needle
9 Instruct the patient to cough in order to spread the solution throughout the trachea

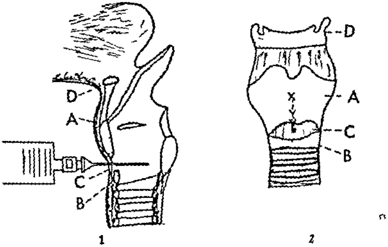


Fig 65 1 Cross section of larynx showing placement of needle in performing transcricoid instillation of local anesthetic drug 2 Anterior view of larynx (A) Thyroid cartilage (B) Cricoid cartilage (C) Thyrocricoid membrane (D) Hyoid bone (X) Point of injection in midline

10 Spray the mouth and pharynx with a nebulizer with the same solution to obtain anesthesia of the epiglottis

Comments

1 For bronchoscopy or endotracheal intubation perform the procedure with the patient sitting up
2 Fix larynx with left hand if it tends to slip about

Complications

1 Possibility of fistulae cellulitis of the neck and thyroiditis
2 Bleeding caused by using too large a needle
3 Broken needle

Pre Anesthetic Intubation With Patient "Awake"

Description The passage of an endotracheal catheter either nasally or orally before the patient is anesthetized

Use

1 In cases in which partial obstruction exists and complete obstruction during induction is feared
2 In cases in which a mask cannot be applied to the face
3 In cases in which the neck cannot be flexed because of fear of causing injury (fractured cervical vertebrae)
4 In cases in which avoidance of tracheotomy is imperative

Materials

a 4% Cocaine—(or 5% hexylcaine, 5% lidocaine (Xylocaine) or 2% pontocaine)
b Spray of Pilling type for laryngeal anesthesia
c Endotracheal tubes, laryngoscopes, etc

Procedure Oral route

1 Advise patient what is to be done and explain procedure Advise he will not be able to talk but will be able to breathe freely after intubation
2 Spray local anesthetic into nostrils and place patient in recumbent position Have patient gargle and expectorate excess
3 Next spray tongue, palate and oropharynx with local anesthetic in 5 pounts not exceeding 1 cc at each time
5 Re McIntosh or Guedal laryngoscope expose the hypopharynx Spray hypopharynx and cords if they can be visualized
5 Allow 3 or 4 minutes to elapse and attempt to visualize larynx Spray again if cough reflex persists
6 Expose larynx and introduce intratracheal catheter of proper size

7 Add 1 cc local anesthetic solution into tube if coughing persists
8 As soon as "bucking" ceases induce anesthesia with pentothal, cyclopropane or other desired agent

Procedure Nasal route

1 Proceed as above to anesthetize nasopharynx, oropharynx and trachea
2 Introduce nasal tube into the most patent nostril and pass into hypopharynx noting point of maximum ventilation at expiration Stop at this point
3 Have patient inspire deeply
4 Introduce catheter quickly during height of inspiration

Comment

1 Transcricoid instillation may be used to anesthetize larynx and hypopharynx if desired This obviates use of laryngoscope to anesthetize hypopharynx
2 Do not administer barbiturates and then attempt intubation Patient becomes disoriented and unmanageable and moves about because reflex activity is only partially obtunded

Intratracheal Anesthesia Utilizing Tracheotomy

Procedure

1 Select anode wire woven catheter same size or larger than tracheotomy cannula
2 Lubricate with local anesthetic ointment (Americaine, Pontocaine, Nupercaine, etc)
3 Introduce gently into tracheotomy opening and guide beveled end into trachea (Fig 66)

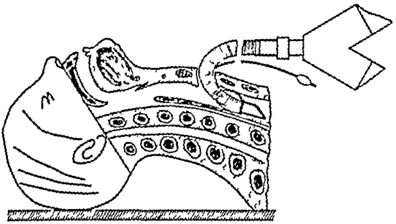


Fig 66 The tracheotomy cannula may be replaced with a wire woven anode endotracheal tube with a cuff which is then connected to the anesthesia apparatus and anchored in position with adhesive Anesthesia is then conducted in the usual manner using the semi closed or closed system with whatever agent is desired

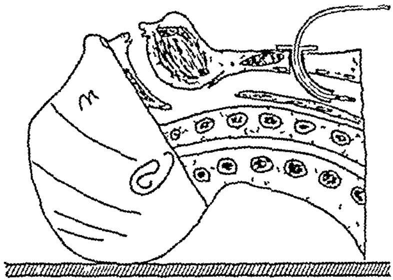


FIG 67 Gases and vapors of volatile liquids may be insufflated directly into the tracheal cannula of a tracheotomized patient The catheter, since it partly occludes the lumen of the cannula, may cause serious obstruction when the cannula fits snugly into the tracheotomy opening

4 Pack area around tube with gauze
5 Anchor tube to skin of neck with adhesive
6 Connect adapter to filter
7 Induce anesthesia with cyclopropane, or other desired agent
8 When jaw is relaxed pack pharynx to prevent supra laryngeal leakage of mixture

Alternate Methods

1 Adapters may be soldered to endotracheal slip joints and connection made directly to tracheotomy cannula
2 Insufflation into the tracheotomy cannula with catheter may be used but is less desirable Catheter partly occludes airway (Fig 67)

Ayres Intratracheal Insufflation Technique

Definition Insufflation of an anesthetic gas or vapor directly into the trachea using a nasal or oral intratracheal catheter connected to a Y piece at the slip joint

Uses

1 For oral or nasal surgery—particularly in infants and in situations in which connectors and slip joints interfere with the surgeon's movements if in the operative field

Materials

1 A metal Y connector whose internal diameter is the same or greater than the diameter of the endotracheal catheter
2 A curved elbow which fits into the intratracheal tube

3 Pieces of gum rubber approximately one inch in length to connect elbow to Y piece

4 Piece of rubber several inches in length with several perforations along

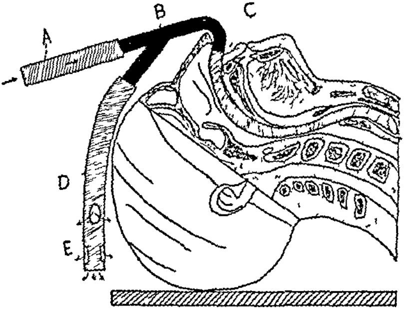


FIG 68 An alternate method of insufflation nasoendotracheal anesthesia Gases are delivered under slight positive pressure through (A) which is connected to the (B) Y" piece which communicates with (C) the nasal tracheal airway (D) Short exhalation and rebreathing tube open at the end (E) Perforations are for the escape of exhaled and excess gases

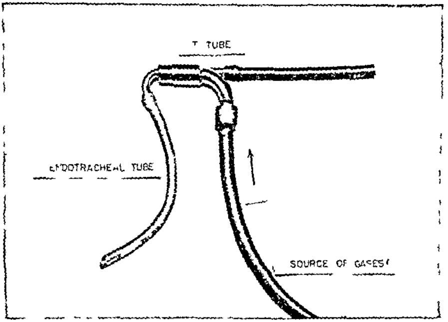


FIG 69 The Ayres insufflation technique embodies the use of a Y tube one limb of which is connected to the source of anesthetic mixture and the other to a short length of perforated tubing The main limb is connected to the endotracheal tube This technique is suitable for surgery of the head and neck in infants and children (Courtesy C R Stephen Elements of Pediatric Anesthesia Springfield, Thomas 1954 Fig 8 p 46)

body which fits Y piece and has approximately same or larger internal diameter of the Y piece (Fig 68, 69)

5 Insufflation apparatus

Procedure

1 Anesthetize subject (preferably with open drop ether) if ether *is to* be used
2 Intubate and insert elbow into Y piece and connect to insufflation apparatus and continue with agent of choice

ENDOBRONCHIAL ANESTHESIA

Definition The introduction of a single catheter into one bronchus or a double lumen catheter into both main stem bronchi so that the lungs no longer communicate with each other Anesthesia is then conducted into one or both bronchi as desired

Indications for Endobronchial Anesthesia

1 For thoracic surgery to prevent drowning from excessive fluids or blood
2 To prevent contamination of the healthy lung by infected material when one is diseased

Technique—Two Lung Endobronchial Anesthesia Using a Carlen's Catheter

Materials

1 A Carlen's double lumen catheter 13 mm outside diameter for males and 11 mm for females (Fig 70)

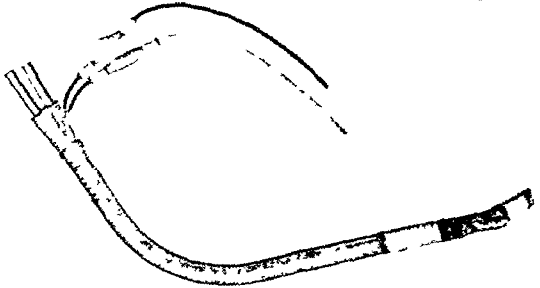


Fig 70 The double lumen endotracheal catheter of Carlens permits isolation of the right bronchus from the left and prevents contaminated material from passing from one lung to the other

2 4% cocaine or other desired topical anesthetic
3 A curved stylet, lubricated
4 Laryngoscope of the Guedel or McIntosh type
5 Double slip joint for intratracheal adapter
6 Suction catheters which pass into the tube

Procedure (With Local Anesthesia)

1 Anesthetize the pharynx, larynx and trachea topically This is done by spraying the naso and oropharynx and by transcricoid instillation or by direct instillation into the larynx
2 Arrange the patient in the sitting position
3 Lubricate the catheter and tie the "carina hook" with a silk thread using a slip knot so that it is close to the tube and can be slipped into the trachea (Fig 71)

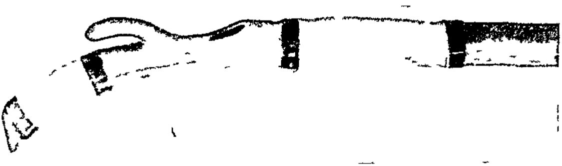


Fig 71 The end of the Carlens catheter is shown

4 Introduce lubricated curved metal stylet into tube
5 Under direct vision introduce tube into larynx using slight rotary movement
6 Gently release slip knot and push the catheter downward It turns automatically to the left
7 Withdraw the curved stylet
8 As soon as the hook is engaged in carina inflate both cuffs (Fig 72)
9 Replace mask over the tube for two lung anesthesia or connect to a circle filter with double adapter Single adapter to desired bronchus is used for one lung anesthesia
10 Commence anesthesia with cyclopropane or other desired agent

Procedure (With General Anesthesia)

1 Prepare patient with topical anesthesia as above
2 Commence general anesthesia with cyclopropane, or other desired agent
3 Administer muscle relaxant, such as syncurine (3–4 mgm) or succinyl choline (20–40 mgm) (See Part IV)

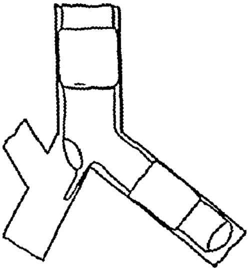


FIG 72 Position of Carlens double lumen endobronchial catheter in the trachea and bronchi. The middle piece hooks over the carina and fixes the catheter in position The catheter passes into the left To prevent occlusion of the eparterial bronchus on the right side the catheter is cut short at the carina The cuffs isolate the right lung from the left

4 Expose larynx with laryngoscope as for endotracheal intubation
5 Introduce catheter as above

Endobronchial Intubation Using Direct Vision

Definition One lung anesthesia obtained by intubating the bronchus under direct vision employing bronchial tube or a catheter slipped over a bronchoscope

Materials Special Ruth Bailey, Bonica, or other desired type endobronchial tube and bronchoscope (Fig 73)

Prepare as Follows

1 Apply Penrose tubing over the coil wire of the airway portion of the Ruth Bailey bronchoscope or apply Bonica catheter over the bronchoscope
2 Lubricate with anesthetic ointment
3 Introduce the light carrier into the bronchoscope

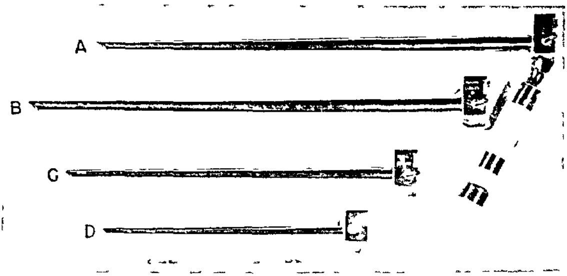
Procedure

1 Anesthetize the patient in the usual manner using cyclopropane and a muscle relaxant or other desired anesthetic which has been preceded by topical anesthesia
2 Expose the trachea with (McIntosh or Guedel) laryngoscope
3 Introduce bronchoscope into the trachea
4 Remove laryngoscope
5 Advance bronchoscope into desired bronchus
6 Insert bite block
7 Remove and adjust light carrier and bronchoscope leaving airway portion of tube in bronchus

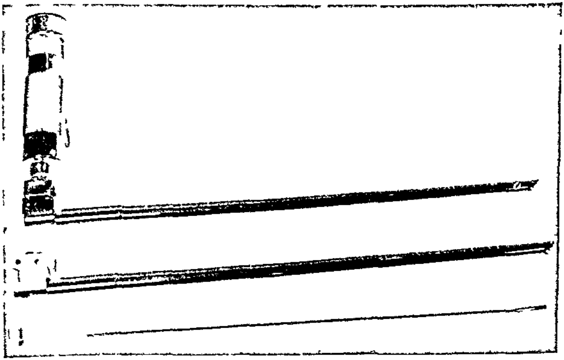
8 Attach to anesthesia apparatus
9 Inflate cuff

Situations for Which Endobronchial Anesthesia Is Desirable

1 Tuberculosis with cavitation or secondary suppuration behind a bronchial stenosis
2 Operations for bronchiectasis with copious secretions

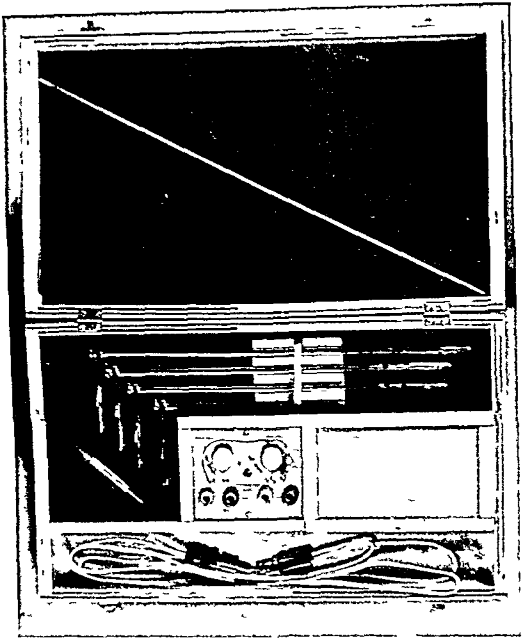


(a)



(b)

Fig 73 Bronchoscopes used for introducing endotracheal catheters and for bronchoscopy for aspiration (a) Davis bronchoscopes (b) Tapered bronchoscopes for aspiration (c) Infant bronchoscopes. (*See page 201 for (c)*)



(c)

3 Purulent lung abscess or lung cysts
4 Cases in which pulmonary bronchial hemorrhage is present or may occur
5 Bronchopleural fistula

Comment

1 The trachea is not cylindrical Its antero posterior diameter is somewhat less than the transverse
2 The distance from the gums to the bifurcation is about 25 cms
3 The trachea lies in the median plane as far as aortic arch after which it is deflected slightly to the right
4 The opening of the right bronchus is equivalent to $\frac{3}{5}$ of the area of the

terminal portion of the trachea The carina thus is to left of midline

5 The right bronchus deviates 25° from the median saggital plane, the left 45°
6 The length of the right bronchus varies from 0 5 to 2 5 cms
7 The eparterial bronchus on the right may be opposite the carina and may be blocked in one lung intubations
8 The right bronchus is wider than the left

Precautions

1 Do not overinflate cuff It may bulge over end and occlude lumen of tube
2 Infiltrate hilum with procaine to obviate tracheobronchial reflexes
3 Ausculate chest to ascertain whether or not ventilation is adequate on the intubated side in one lung intubations

Advantages

1 Prevents drowning of the patient in his own secretions when aspira tion with an ordinary endotracheal tube does not prevent the secre tions from the diseased lung passing into the healthy one
2 Reduces the necessity for preoperative bronchoscopy
3 Allows operations to be performed on a completely collapsed lung
4 Prevents loss of anesthetic gas through a bronchopleura fistula
5 Reduces incidence of contralateral atelectasis
6 Decreases the number of aspirations during surgery as the functioning lung does not become "wet "
7 Permits the diseased lung to be deflated to provide greater operating space in the chest
8 Permits lung to be inflated when lobar or intersegmental planes are de veloped
9 Permits bronchus to be divided whenever this is suitable and left open until it is convenient to close it
10 Relieves the necessity of applying clamp on the proximal part of the bonchus thus avoiding injury to the bronchial wall
11 Permits removal of foreign material
12 Permits inspection of the bronchus and aspiration through the opening in the open bronchus

Disadvantages

1 Necessitates the use of deep anesthesia
2 Skill is required in bronchoscopic technique
3 Possibility of trauma to the bronchus from the tube is present
4 The cuff may be over-distended and obstruct the lumen of the bronchus

5 The eparterial bronchus may be occluded on the intubated side
6 The tube may become displaced during operation without notice of the anesthesiologist and asphyxia results
7 The cuff may be partially deflated and permits passage of secretions around the tube
8 The cuff must be deflated (in single catheter technique) when positive pressure is made to check if the bronchus is air tight following ligation and severance
9 Cross sectional area of trachea may be reduced unduly

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Insufflation Intratracheal Anesthesia

Principle The patient is intubated by the nasal or oral route and a smaller catheter is passed through the tube to the bifurcation of the trachea Ether oxygen is conducted into the lungs through the smaller tube and the gases return through the larger one (Fig 74)

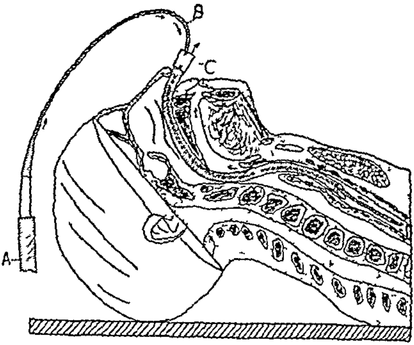

Fig 74 Intratracheal insufflation anesthesia (A) The delivery tube from source of anesthetic gases and vapors is connected to (B) the lubricated catheter which is threaded through (C) the nasotracheal tube The inner catheter protrudes beyond the bevel of the outer one and extends as far as the carina Gases and vapors are delivered under a positive pressure not exceeding 25 mm Hg They return through the larger catheter or between the tracheal wall and catheter and pass through the nose and mouth

terminal portion of the trachea The carina thus is to left of midline

5 The right bronchus deviates 25° from the median saggital plane, the left 45°
6 The length of the right bronchus varies from 0 5 to 2 5 cms
7 The eparterial bronchus on the right may be opposite the carina and may be blocked in one lung intubations
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Precautions

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Disadvantages

1 Necessitates the use of deep anesthesia
2 Skill is required in bronchoscopic technique
3 Possibility of trauma to the bronchus from the tube is present
4 The cuff may be over-distended and obstruct the lumen of the bronchus

	vagal reflexes, obstruct the end of the catheter, or denude the mucosa from the trachea
2 Do not inflate the cuff during light anesthesia	Distension of the cuff often elicits a violent cough reflex
3 Do not use old non elastic cuffs	They are usually elongated and cover an excess area of the tracheal surface
4 Do not use a cuff which possesses too thin a wall	It may bulge over the end of the catheter and obstruct the lumen
5 Do not use a cuff whose walls are too thick	The pressure required to inflate the cuff may be so great that it compresses a soft intratracheal catheter
6 Always test cuffs by inflating them and submerging in water Fine bubbles will appear if a leak is present	Small leaks are vexing and not easily detected
7 Do not use cuffs which do not grip the catheter firmly	The cuff may slip off the catheter during extubation

General Comment Concerning Intratracheal Anesthesia	*Reasons*
1 Select the route of intubation which is most convenient to the surgeon and safest for the patient	The catheter should not be in the operative field
2 Select the route which promises to be the least traumatic	Edentulate subjects or subjects with long, thin necks are more easily intubated by direct vision Subjects with short necks are more easily intubated by the nasal route
3 Intubate subjects with short, thick necks or with fragile or loose teeth by the nasal route	The larynx is difficult to expose with the laryngoscope in these subjects but the nasal catheter by the "blind" technique slips in easily
4 Avoid nasotracheal intubation in infants and children	Adenoids and anatomical abnormalities are more common in children and interfere with the intubation
5 Remember that the pharyngeal reflex, as well as the laryngeal reflex, is obtunded in debilitated subjects, patients in shock, etc	This lack of activity facilitates intubation under light anesthesia, or without any anesthesia
6 Remember that the pharyngeal reflex is hyperactive in subjects	Intubation is more difficult in these subjects because of this in

Materials

1 An oral or nasal tracheal catheter
2 The usual intubation equipment
3 Catheter #18 F or smaller if a tracheal catheter of small bore is used
4 Inhaler
5 Insufflation apparatus for ether

Technique

1 Anesthetize and intubate the patient
2 Attach catheter to insufflation apparatus consisting of an ether vaporizer and oxygen supply
3 Commence the flow of ether vapor through catheter at pressure of 10–20 cms H_2O
4 Lubricate catheter well and introduce it into the trachea as far as its bifurcation
5 Continue anesthesia in the usual manner

Care of Catheters

1 Cleanse the lumen with soap and water Use a test tube brush or a gauze ribbon to remove all foreign particles
2 Remove the lubricant with ether Adhesive should be soaked with ether before removal, otherwise rubber may be torn
3 Rinse with soapy water, then water, and immerse in mercuric cyanide solution (1 1000) for an hour
4 Rinse with water Follow with 70% alcohol and dry

Use and Care of Cuffs

Inflation

1 Insert the short blunt needle into lumen of catheter leading to cuff
2 Attach the 10 cc dry syringe filled with air
3 Inject air gently and slowly into the cuff until a resistance is felt on the plunger Manually compress the breathing bag as the cuff is distended
4 Clamp catheter when the gases no longer escape and the seal is complete Remove syringe

Cleaning

1 Remove the cuff from the catheter and cleanse in the same manner described above for catheters

Comment	*Reasons*
1 Do not over-inflate cuffs	They may rupture and cause trauma to the trachea, initiate

	vagal reflexes, obstruct the end of the catheter, or denude the mucosa from the trachea
2 Do not inflate the cuff during light anesthesia	Distension of the cuff often elicits a violent cough reflex
3 Do not use old non elastic cuffs	They are usually elongated and cover an excess area of the tracheal surface
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5 Remember that the pharyngeal reflex, as well as the laryngeal reflex, is obtunded in debilitated subjects, patients in shock, etc	This lack of activity facilitates intubation under light anesthesia, or without any anesthesia
6 Remember that the pharyngeal reflex is hyperactive in subjects	Intubation is more difficult in these subjects because of this in-

with pulmonary disease, in subjects with purulent discharge from the lungs, or in children	creased activity
7 Select small catheters when the open, oral, or nasal technique is employed	Trauma is lessened Gases pass in and around catheter
8 Use silk, metal, or anode tubes when the head is to be extended or flexed, or when patient is to be placed in any position other than on his back	Soft catheters are easily kinked in these situations
9 Use the closed endotracheal technique with an inflatable cuff or packs for oral surgery or when emesis or regurgitation is anticipated	Aspiration of secretions is assured only by a closed system

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PART III

COMPLICATIONS OF ANESTHESIA

COMPLICATIONS DURING GENERAL ANESTHESIA

Although many undesirable reactions and complications appear during general anesthesia, those of major importance may be divided into four groups *respiratory, circulatory, neurological,* and *technical*

Respiratory Complications

Respiratory complications are the most vexing and frequent complications of anesthesia If unrecognized and untreated, they ultimately lead to asphyxia The following symptoms and complications are the most important

Anoxia

Definition Interference with adequate oxygenation of tissues

Causes

1 A decreased oxygen tension in the inspired air
2 Obstruction of the airway
3 Impairment of pulmonary ventilation from
   a Overdosage of depressant drugs
   b Restraint of thoracic and diaphragmatic movements
   c Decrease in vital capacity by mechanical methods, such as pneumo thorax
   d Alterations in permeability of pulmonary epithelium
   e Pulmonary edema
4 Impairment of oxygen transport—carbon monoxide poisoning or circu latory disturbances
5 Inability of tissues to utilize oxygen—cyanide and similar types of poisoning

Sequelae

1 Circulatory failure, if immediate treatment is instituted and recovery follows
2 Circulatory failure followed by a delay in treatment In these instances death may be delayed for several hours or the patient may recover but may have signs and symptoms of cerebral damage
3 Circulatory failure and death within a few minutes

Cyanosis

Definition The bluish discoloration of the skin and mucous membrane due to an increase or excess of reduced hemoglobin in the blood

Factors Influencing Its Appearance

1 The quantity of reduced hemoglobin in the blood (usually 6 gms per 100 cc blood must be present)

2 The thickness of the skin—the thicker the skin the less intense the color
3 The size and degree of dilatation of cutaneous vessels
4 The degree of pigmentation of the skin
5 Acuity of the observer

Causes

1 Decreased oxygen tension in the alveoli
  a Respiratory obstruction (page 218)
  b Decreased partial pressure of oxygen in the inhaled mixture
  c Decreased ventilation from respiratory depression, respiratory failure, interference with respiratory movements, or diminished vital capacity
2 Slowing of circulating blood through the capillaries from
  a Circulatory failure
  b Compression of a vessel or an extremity

Comment	*Reasons*
1 Cyanosis is no index of depth of anesthesia	It merely indicates the state of oxygenation of the blood
2 Cyanosis may not appear in severe anemias	The amount of reduced hemoglobin may not be sufficient for it to be visible through the skin

Hyperpnea During Anesthesia

Definition An abnormally excessive rate or depth of respiration

Causes

1 Carbon dioxide excess (see hypercapnia)
2 Painful stimulation during light anesthesia
3 Local stimulating action of the anesthetic drug used in conjunction with inhalation anesthesia
4 Central disturbances—intracranial lesions

Apnea During Anesthesia

Definition A cessation of respiratory movements or ventilatory efforts

Causes

1 Hypocapnia from hyperventilation and raising the threshold of the respiratory center to carbon dioxide
2 Reflex stimulation of pharynx, trachea, hilum, mesentery, etc
3 Overdosage of central nervous system depressants
4 Laryngeal or bronchial spasm
5 Complete obstruction of the airway
6 Neurological disturbances, particularly increased intracranial pressure, etc

7 Circulatory failure (shock or cardiac arrest) (See overdosage, this chapter, for discussion and differential diagnosis)
8 Overdistension of breathing bag

Hypopnea During Anesthesia

Definition Decreased tidal exchange without a notable decrease in respiratory rate

Causes

1 Depression of medullary centers due to drugs particularly nonvolatile central nervous system depressants
2 Increased positive pressure in the inhalor—over distended bag
3 Decrease in pulmonary ventilating surface such as is seen with pneumothorax mediastinal shift during chest surgery or atelectasis
4 Cessation of painful stimulation during light anesthesia
5 Lightening of anesthesia or discontinuing administration of drugs which cause exaggerated breathing (ether)
6 Obstructed airway
7 Awkward positions interfering with proper ventilation
8 Carbon dioxide excess which has persisted to point of causing depression of medullary centers

Management

1 Remove obstruction or other cause of interference with ventilation
2 Increase oxygen tension in inhaler
3 Reduce pressure in inhaler so that bag is partially deflated

Bradypnea

Definition Slow rate of respiration with or without a decrease in minute volume exchange Tidal volume may increase to compensate for decrease in rate

Causes

1 Depression by narcotics (morphine, dilaudid, etc)
2 Severe anoxia, terminal phase
3 Central lesions which cause increased intracranial pressure
4 Peripheral or central circulatory failure

Management

1 Be certain airway is patent and oxygenation is adequate
2 Augment or control respiration when ventilation is not adequate
3 Administer nalorphine (Nalline) if due to narcotics
4 Reduce intracranial pressure if due to central lesions
5 Administer circulatory stimulants, blood or fluids if due to failure of circulation

Polypnea

Definition An increase in both depth and rate of respiration

Causes

1 Anoxia—in early precrisis phases due to deficient oxygen tension in inspired mixture
2 Local stimulating action of volatile drugs (ether, ethyl chloride, etc)
3 Painful stimulation during light anesthesia or stimulation of hyper esponsive areas
4 Carbon dioxide excess approaching peak of stimulation
5 Central lesions causing derangement of respiratory center

Management

1 Increase oxygen tension in inhalor if due to anoxia
2 Check carbon dioxide absorber, mask size or other sources of dead space which permits rebreathing
3 Deepen anesthesia if due to stimulation or use procaine block in hy peresponsive areas
4 Shift to non stimulating agents such as cyclopropane or pentothal nitrous oxide, and use controlled respiration

Tachypnea

Definition An excessive rate of respiration

Causes

1 Local stimulating action of volatile drugs (ether, ethyl chloride, etc) but especially trichlorethylene (trilene)
2 Painful stimulation during light anesthesia or stimulation of hyper esponsive agents
3 Central disturbances due to neurological lesions
4 Anoxia due to inadequate oxygenation of inhaled mixture
5 Undersized endotracheal airways

Management

1 Oxygenate well
2 Inspect absorber, valves, tubing, etc
3 Eliminate or decrease size of dead space in masks, connectors, etc
4 Deepen anesthesia if light when sensitive structures are manipulated (rectum, perineum, penis, vulva, periosteum, etc)
5 Reduce intracranial pressure in central lesions by proper neurological measures recommended for the cause

Hyperpnea During Anesthesia

Definition An abnormally excessive depth of respiration resulting in an increased minute volume exchange

Causes

1 Carbon dioxide excess (see hypercapnia)
2 Painful stimulation during light anesthesia or stimulation of a hyperesponsive area
3 Local stimulating action of the anesthetic drug (ether, etc) used in conjunction with inhalation anesthesia
4 Central disturbances—intracranial lesions
5 Cause undetermined

Management

1 Check absorbent and replace with fresh if any doubt exists concerning freshness
2 Close main valves on carbon dioxide cylinders if present on apparatus
3 Change mask to smaller one if possible to eliminate rebreathing as much as possible
4 Deepen anesthesia if light and manipulations are painful
5 Change to cyclopropane or pentothal nitrous oxide or ethylene if due to ether or other volatile liquid
6 Reduce intracranial pressure by proper neurosurgical measures if due to neurological lesion
7 Curarize and control respiration if above fail and respiratory movements interfere with operation

Periodic Breathing

Definition A progressive increase in depth of respiration which reaches a peak and gradually recedes which recurs at regular intervals which appears during general anesthesia

Causes

1 Marked or long standing depression of respiratory center due to non volatile drugs (barbiturates)
2 Decrease in volume of anatomical dead space (during intratracheal anesthesia) causes more abrupt mixing of tidal air with alveolar air
3 Central lesions cause medullary compression and inactivate respiratory center

Management

1 Augment breathing if due to depression by drugs
2 Use analeptics if due to medullary depression caused by drugs

3 Increase dead space in intratracheal anesthesia
4 Reduce intracranial pressure by dehydration or neurosurgical measures if due to central lesions

Irregular Breathing

Causes

1 Central nervous system diseases which cause increased intracranial pressure and affect respiratory center
2 Intermittent partial obstruction
3 Second stage anesthesia
4 Reflex due to stimulation of peritoneum, pleura, viscera, periosteum, rectum, genitalia and other hyperesponsive areas

Management

1 Be certain airway is not obstructed
2 Remove stimulus to hypersensitive structures by procaine block
3 Determine and remove cause if due to central lesion

Difficult Breathing During Anesthesia

Definition Difficult, labored, or gasping respiration Inspiration, expiration or both phases of respiration may be abnormal Tracheal tug may be present

Causes

1 Partial obstruction in the respiratory tract (see obstruction)
2 Difficult position, particularly prone, head down supine or lateral
3 External force inhibiting thoracic movements
4 Decreased vital capacity due to disease of lung (atelectasis or fibrosis)
5 Hypercapnia, particularly when sustained for a long time and high concentrations of carbon dioxide accumulates in the inhaler
6 Chronic sub-oxygenation
7 Pneumothorax or other factors decreasing ventilating surface or minute volume exchange
8 Biochemical disturbances due to anoxia or carbon dioxide excess
9 Faulty apparatus causing obstruction, particularly on inspirations
10 Atelectasis developing during anesthesia
11 High spinal anesthesia involving intercostal muscles
12 Central derangements due to neurologic disease
13 Fourth plane anesthesia

Management

1 Establish airway Intubate if necessary to improve ventilation
2 Assist or use controlled respiration to provide adequate ventilation

3 Restore to position which eliminates interference with respiration
4 Introduce needle and water trap if due to pneumothorax

DYSPNEA

Definition Sensation of suffocation or inability to breathe of which patient complains Occurs during regional anesthesia while patient is conscious

Causes

1 Spinal is high involving intercostal muscles
2 Prodromal response to overdosage of local anesthetic
3 Psychogenic factors ensuing from apprehension
4 Aggravation of pre existing cardiac or pulmonary disease

Management

1 Sedate with intravenous narcotic or basal narcotic doses of barbiturates if due to apprehension
2 Administer oxygen and assist breathing if due to high spinal
3 Adjust position, administer oxygen and narcotics if due to cardiac and pulmonary disease

COUGHING DURING ANESTHESIA

Causes

1 Artificial airways or laryngoscopes stimulate reflex activity in the pharynx, larynx, or trachea when introduced in second stage or during basal narcosis with non-volatile drugs or in subjects with hyperactive cough reflexes
2 Mucous and other secretions which have accumulated in the pharynx pass into the larynx and trachea and stimulate tracheal reflexes
3 Strong concentration of ether or other irritating volatile agent suddenly introduced into the inhaler (this elicits a cough even when the patient is in surgical anesthesia)
4 Manipulation of the wall of a bronchus, hilum of a lung, or trachea in thoracic or neck surgery
5 Hyperactive cough reflex Common in supurative diseases of lung

Management

1 Avoid placement of airways in second stage anesthesia or during basal narcosis
2 Suction secretions thoroughly—administer additional anticholinergic drug if dose has been inadequate
3 Use topical anesthesia prior to intubation and coat airways with ra[illegible] acting anesthetic ointments (Americaine—20% benzocaine [illegible])
4 Instill 1–2 cc 4% cocaine into intratracheal tubes if due to tu[illegible]

3 Increase dead space in intratracheal anesthesia
4 Reduce intracranial pressure by dehydration or neurosurgical measures if due to central lesions

Irregular Breathing

Causes

1 Central nervous system diseases which cause increased intracranial pressure and affect respiratory center
2 Intermittent partial obstruction
3 Second stage anesthesia
4 Reflex due to stimulation of peritoneum, pleura, viscera, periosteum, rectum, genitalia and other hyperesponsive areas

Management

1 Be certain airway is not obstructed
2 Remove stimulus to hypersensitive structures by procaine block
3 Determine and remove cause if due to central lesion

Difficult Breathing During Anesthesia

Definition Difficult, labored, or gasping respiration Inspiration, expiration or both phases of respiration may be abnormal Tracheal tug may be present

Causes

1 Partial obstruction in the respiratory tract (see obstruction)
2 Difficult position, particularly prone, head down supine or lateral
3 External force inhibiting thoracic movements
4 Decreased vital capacity due to disease of lung (atelectasis or fibrosis)
5 Hypercapnia, particularly when sustained for a long time and high concentrations of carbon dioxide accumulates in the inhaler
6 Chronic sub-oxygenation
7 Pneumothorax or other factors decreasing ventilating surface or minute volume exchange
8 Biochemical disturbances due to anoxia or carbon dioxide excess
9 Faulty apparatus causing obstruction, particularly on inspirations
10 Atelectasis developing during anesthesia
11 High spinal anesthesia involving intercostal muscles
12 Central derangements due to neurologic disease
13 Fourth plane anesthesia

Management

1 Establish airway Intubate if necessary to improve ventilation
2 Assist or use controlled respiration to provide adequate ventilation

4 Obtund or block noxious stimuli arising from thoracic structures Use procaine block if possible or anticholinergic agent intravenously
5 Curarize and use controlled respiration if persistent and due to hyperresponsive reflexes

Sneezing

Causes

1 Inhalation of irritating vapors (high concentrations of ether) during hypnosis with non volatile drugs
2 Stimulation of the cornea during eye surgery performed with basal narcosis induced with ultra short acting barbiturates

Management

1 Use topical anesthesia for occular surgery requiring stimulation of cornea

Hiccoughs

Definition Abrupt periodic contraction of diaphragm Usually impedes and annoys surgeon

Characteristics

1 Usually occurs during upper abdominal surgery particularly in stomach
2 Occurs under both general or regional anesthesia Common with pentothal and regional anesthesia
3 During general anesthesia associated with inadequate ventilation—obstruction or CO retention

Causes

1 Stimulation of phrenic nerve by pinching with clamps or traction on areas supplied by nerve
2 Hypoventilation with carbon dioxide accumulation particularly in electrolyte imbalance
3 Distended or dilated stomach
4 Infections and traumatic conditions in area of diaphragm
5 Undetermined

Treatment

1 Improve airway and hyperventilate patient to remove excess CO
2 Seek and remove or block possible offending stimuli to phrenic or vagus nerves
3 Decompress stomach
4 Change agents, particularly those which cause CO_2 retention

5. Reduce concentration of volatile agent or change to non irritating type agents if cough persists
6. Block hyperesponsive area with procaine (hilum) or topically with cocaine
7. Curarize and control breathing if due to hyperactive cough reflex which does not respond to addition of topical anesthetic agents and deepening of anesthesia

Sighing

Definition Sudden deep inspirations appearing at irregular intervals without apparent cause during anesthesia

Causes (1) Light anesthesia accompanied by CO excess or anoxia usually preceeded by excitement or crying during induction Common during ether anesthesia in children

Prophylaxis

1. Premedicate patient well
2. Avoid obstruction during induction of anesthesia
3. Avoid secretions

"Bucking"

Definition Spasmodic inspiratory and expiratory gasps due to stimulation of tracheal and bronchial reflexes Usually occurs during thoracic surgery or intubation

Causes

1. Hilar, tracheal, bronchial or pleural stimulation in thoracic surgery
2. Lightening of anesthesia when endotracheal tube is in place
3. Stimulation due to airways, catheters, and bronchoscopes during light anesthesia
4. Flooding of tracheobronchial tree by secretions, blood or pus, particularly if spasmogenic (thiobarbiturates) agents are used
5. Traction of diaphragm or manipulation of pericardium, pleura and other structures in or about the thorax
6. Intratracheal catheter is in a bronchus
7. Subject cannot tolerate agent (ether) due to extremely active tracheobronchial reflexes

Management

1. Clear airway of all secretions by suctioning
2. Use topical anesthesia prior to placement of airways
3. Supplement topical anesthesia by instillation of cocaine 2 cc —4% into intratracheal tube

4 Obtund or block noxious stimuli arising from thoracic structures Use procaine block if possible or anticholinergic agent intravenously
5 Curarize and use controlled respiration if persistent and due to hyperresponsive reflexes

SNEEZING

Causes

1 Inhalation of irritating vapors (high concentrations of ether) during hypnosis with non volatile drugs
2 Stimulation of the cornea during eye surgery performed with basal narcosis induced with ultra short acting barbiturates

Management

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Causes

1 Stimulation of phrenic nerve by pinching with clamps, or traction on areas supplied by nerve
2 Hypoventilation with carbon dioxide accumulation particularly in electrolyte imbalance
3 Distended or dilated stomach
4 Infections and traumatic conditions in area of diaphragm
5 Undetermined

Treatment

1 Improve airway and hyperventilate patient to remove excess CO_2
2 Seek and remove or block possible offending stimuli to phrenic or vagus nerves
3 Decompress stomach
4 Change agents, particularly those which cause CO_2 retention

5 Instill cocaine (1 cc 4%) or other topical anesthetic into intratracheal tube
6 Administer a muscle relaxant and control respiration if spasms interfere with surgery and other measures fail

Comment	*Reason*
1 Do not use carbon dioxide	This may aggravate rather than remove cause

NOISY RESPIRATION

Causes Vibrations in the respiratory passages as the tidal air passes through narrowed orifices, over secretions, over relaxed tissues, etc It is a symptom of respiratory obstruction or inadequate pulmonary ventilation (see obstruction, laryngeal spasm, hypercapnia)

HYPERCAPNIA

Definition The presence of carbon dioxide in excess in the blood resulting in stimulation of respiration

Symptoms

1 Hypertension with no change or a slight increase in pulse rate (this is an almost constant symptom)
2 Hyperpnea this is followed by depression of respiration and gasping type of respiratory activity
3 Twitching of muscles, followed by convulsions, usually generalized if the accumulation is excessive
4 Increase in depth of narcosis
5 Cardiac arrhythmias
6 Phonation, crowing, wheezing, and other forms of noisy respiration

Causes

1 Soda lime is exhausted
2 The "dead space" in mask, adapters, and other attachments is out of proportion to the tidal volume and causes excessive rebreathing
3 Carbon dioxide supply from the flowmeter is not turned off
4 Exhalation valves on inhaler or shunts on filters are defective so that carbon dioxide returns to the mask
5 Carbon dioxide cylinder may be attached to a yoke intended for another gas
6 Oxygen or other gases may be contaminated with carbon dioxide

Sequelae If carbon dioxide is allowed to accumulate in the inhaler, the point of stimulation is passed and the phase of depression follows Toxic effects

manifested by dyspnea, circulatory changes, and neuromuscular phenomena appear

Excess Mucus Secretion

Source Mucus is secreted by the salivary and mucous glands of the pharynx, larynx, and trachea

Causes

1 Premedication of atropine or scopolamine omitted, insufficient, or not administered at the proper time
2 Concentration of anesthetic drugs is high
3 Drug may stimulate mucous glands to activity (vinethene)
4 Anoxia or excitement during induction period
5 Administration of parasympathetic stimulating drugs or sympathetic depressants during surgery
6 Use of iodides (thyroidectomy)

Treatment

1 Lower head of patient in order to allow secretions to gravitate into the nasopharynx
2 Apply suction, using metal suction tip or catheter
3 Resort to bronchoscopy in severe cases
4 Supplement atropine with additional drug intravenously
5 Change agent if due to drug

Pulmonary Edema During Anesthesia

Definition Transudation of fluid from the capillaries of the pulmonary circulatory system into the alveoli

Causes

1 Increased pulmonary venous pressure from
   a Cardiac failure, selection of improper agent or technique, change in posture (Trendelenburg)
   b Excessive amounts of intravenous fluids
2 Protracted or excessive negative pressure in the alveoli (obstruction to inspiration from spasm of the larynx, defective apparatus, small airways, etc)
3 Alteration of permeability of epithelium or endothelium (toxic agents such as nitric oxide—impurity of nitrous oxide, aspiration of vomitus)
4 Central lesions

Symptoms

1 Noisy respiration
2 Dyspnea, cyanosis, and other signs of respiratory obstruction

3 Frothy blood tinged fluid in trachea and lungs
4 Increased venous pressure

Treatment

1 Locate cause and remedy it
2 Administer oxygen under pressure (5 to 15 cms H_2O pressure) by mask
3 Reduce pulmonary venous pressure by phlebotomy or dehydration
4 Suction secretions from respiratory tract
5 Incline patient with "head up and feet down"
6 Increase peripheral venous stasis by applying tourniquets
7 Administer atropine gr 1/150–1/100
8 Digitalize patient if due to cardiac failure
9 Induce hypotension with ganglionic blocking agent to reduce blood in lungs by pooling in periphery
10 Inhalation of alcohol to reduce surface tension (Part IX)
11 Administer bronchodilators such as aminophylline

Obstruction of the Airway

Definition of Airway The pathway for the inspired and expired gases extending from the nostrils to the alveolar membrane

Importance of Patent Airway The most common and pernicious complication of inhalation and other forms of anesthesia is the obstruction of the airway This condition leads to anoxemia, carbon dioxide retention, and inability to anesthetize the patient because the drug does not readily pass into the lungs

Causes of an Obstructed Airway	*Comment*
1 Relaxation of tissues	The muscles of the neck, tongue, or pharynx are relaxed and block the passageway The epiglottis sags in front of the glottis
2 Spasm of larynx	The spasm may be partial or complete (see laryngeal spasm)
3 Foreign body	Vomitus, clots, artificial teeth, etc, may lodge in the respiratory tract
4 Secretions	Mucus, saliva, or purulent material from abscesses accumulate in the respiratory tract and interfere with the passage of gases
5 Anatomical defects	Tumors, enlarged tonsils, polyps, stenosis, collapse of the trachea, and edema of the larynx interfere with adequate exchange

6 Faulty artificial airways	These may be of improper size or improperly inserted, kinked, or plugged with secretions
7 Bronchospasm	This is due to vagal stimulation, asthma, or other causes
8 Defective apparatus	Stiff valves, narrow apertures in joints or tubes, or adapters, wet or fine mesh soda lime, long tubes, or empty breathing bag, cause partial obstruction
9 Unsatisfactory posture	The prone or Trendelenburg positions, hyperflexion or hyperextension of the head often interferes with adequate exchange
10 Inhibition of thoracic movements	This often results when assistants lean on the chest or straps, bandages, or casts are too tight

Symptoms of Obstruction	*Comments*
1 Noisy respiration	Manifested by crowing, snoring, or wheezing either during the inspiratory or expiratory phase of respiration
2 Labored respiration	Occurs in partial obstruction The tidal volume is not in proportion to respiratory effort This is characterized by an exaggerated motion of the thorax and only a slight motion of the breathing bag
3 Elevation of blood pressure	Usually due to CO_2 excess, anoxia, or both
4 Rapid pulse	Bradycardia in severe obstruction Arrhythmias may also be prevalent
5 Cyanosis	Noted particularly in severe or prolonged obstruction

Maintenance of Patent Airway During Anesthesia

1 Extend the head so that the chin points directly toward the ceiling (Fig 75) Support head on a small pillow
2 Insert an artificial airway, assists in support of pharyngeal airway if manual support is ineffective
3 Remove mucus or other secretions by use of suction
4 Remove or correct external factors which interfere with respiratory movements, such as poor position

3 Frothy blood tinged fluid in trachea and lungs
4 Increased venous pressure

Treatment

1 Locate cause and remedy it
2 Administer oxygen under pressure (5 to 15 cms H_2O pressure) by mask
3 Reduce pulmonary venous pressure by phlebotomy or dehydration
4 Suction secretions from respiratory tract
5 Incline patient with "head up and feet down"
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3 Foreign body	Vomitus, clots, artificial teeth, etc, may lodge in the respiratory tract
4 Secretions	Mucus, saliva, or purulent material from abscesses accumulate in the respiratory tract and interfere with the passage of gases
5 Anatomical defects	Tumors, enlarged tonsils, polyps, stenosis, collapse of the trachea, and edema of the larynx interfere with adequate exchange

4 Appearance of cyanosis with some agents, but not necessarily all (cyclopropane)
5 Complete depression of nervous system The depression is manifested by absent reflexes and complete relaxation of tissues Pupils are usually dilated and do not react to light
6 Thorax is easily inflated if airway is patent

Treatment

1 Discard all anesthetic mixture from the inhaler and replace with oxygen
2 Institute artificial respiration immediately
3 Remove excess anesthetic drug from lungs

Differentiate from

1 "Breath holding" This is frequently observed in stages I or II, but not in stage III Associated *characteristics* are
   a Voluntary or semi-voluntary action
   b Normal or increased muscle tone
   c Exhibition of swallowing movements by patient
   d Presence of "lid lag" and other eye reflexes
2 Medullary depression This may be due to depression from premedication, other non-volatile drugs, cyclopropane following relief of anoxia, hyperventilation (not always easy to diagnose) *Characteristics* are
   a No abolition of reflexes (laryngeal and other reflexes present)
   b Normal muscle tone
   c Light anesthesia indicated by eye signs
   d Normal or elevated blood pressure
3 Laryngeal spasm This may be due to a variety of causes (page 223) *Characteristics* are
   a Eye signs, those of light anesthesia
   b Difficult insufflation of thorax (does not inflate at all in complete spasm)
   c Wheezing or crowing on inflation and deflation of thorax
   d Elevation of blood pressure
   e Slow, bounding pulse
4 Hypopnea This follows either voluntary (during induction) or manually induced hyperventilation The addition of carbon dioxide restores respiratory rhythm *Characteristics* are
   a Color of skin, usually remains normal (no cyanosis appears)
   b Quality and rate of pulse unchanged
   c Blood pressure unchanged or lowered slightly
   d Reflexes of eye active during light anesthesia—tissues not relaxed
5 Reflex apnea This is due to reflexes caused by stimulation of various structures Commonly encountered *reflexes* are
   a Pharyngeal—the apnea usually occurs when the patient passes from

Results of Acute Complete Obstruction Asphyxia, circulatory and respiratory failure follow unless treatment is instituted promptly Post anesthetic circulatory, respiratory, or central nervous system derangements may follow if treatment is delayed

Results of Continued Partial Obstruction

1 Circulatory changes manifested by tachycardia, rise in blood pressure, bounding pulse, etc
2 Respiratory disturbances, manifested by gasping type of respiration, cyanosis, mucus formation, dyspnea
3 Pulmonary edema, if obstruction is principally inspiratory
4 Pathological changes in the central nervous system, particularly in the cortical cells and various centers

FIG 75 Manner of maintaining a free airway in anesthetized or comatose subjects The chin must be extended upward so that structures in the neck are elevated

Comment

1 Noisy respiration is obstructed respiration and should never be tolerated
2 Obstructed respiration may often be noiseless, particularly if respiration is depressed
3 Any anesthetic procedure which removes the anesthetist from the air way so that he no longer has control over it is not a safe procedure (example—intravenous anesthesia in operations about face or head, when head is inaccessible to anesthetist)
4 The maintenance of a free, unobstructed airway is the most important duty of an anesthetist

MANAGEMENT OF OVERDOSAGE OF INHALATION ANESTHETIC DRUGS

Definition Overdosage occurs when the concentration of the anesthetic drug in the nervous system becomes sufficient to depress the vital centers in the medulla The respiratory center is the first of these centers to be depressed by the currently employed inhalation anesthetic agents It is then no longer capable of sending out rhythmical impulses

Symptoms

1 Absence of respiratory movements of the thorax and diaphragm
2 Pulse palpable at first, but quickly disappears if the apnea persists and treatment is delayed
3 Blood pressure falls rapidly and is often not obtainable

7 Circulatory failure (sudden cardiac arrest) respiratory failure is secondary to circulatory failure *Characteristics* are
  a Absence of pulse, blood pressure, and heart sounds
  b Complete relaxation of tissues
  c Blue or grey cyanosis—not relieved by artificial respiration
  d Eyeballs fixed, pupils in mid dilatation, do not react to light
  e Vocal cords relaxed and thorax is easily inflated

8 Depression of the medullary centers from other than anesthetic drugs Apnea of this type is usually caused by an increase in intracranial pressure, cerebral hemorrhage, neoplasms, or abscesses, etc *Characteristics* are
  a Accompanies cerebrospinal surgery
  b Circulation usually well maintained if effective artificial respiration is practiced
  c Signs such as unequal pupils, nystagmus, spasticity, and exaggerated reflexes revealed by neurological examination

Comments	*Reasons*
1 If in doubt concerning the etiology, treat any apnea as though an overdose of the drug has been administered	The circulation may fail in overdosage if artificial respiration is not instituted immediately
2 Institute artificial respiration immediately Do not waste time administering analeptic drugs	Only ventilation of the lungs can remove the excess drug from the alveoli and supply the needed oxygen to the blood
3 In performing artificial respiration, empty the mixture from the inhaler after every three or four inflations of the breathing bag and replenish with pure oxygen	The anesthetic drug in the alveoli must be removed from the inhaler to allow elimination of the drug from the alveoli
4 Resume anesthesia when normal respiration has been established	The patient may "recover" from narcosis, particularly if anesthesia has been in progress only a short interval
5 Do not become panic stricken and frantically compress thorax at random when apnea occurs	Such movements are useless and usually serve to force valuable oxygen from thorax, particularly if spasm of the larynx is present

Management of Laryngospasm

Definition Laryngeal spasm is a spasm of the adductor muscles of the vocal cords which causes a partial or complete obstruction to the natural airway The spasm may be *complete* or *partial*

Symptoms *Partial spasm* Wheezing, crowing, grunting, phonation, and

stage III to stage II, particularly when an oropharyngeal or oro nasal airway is in place *Characteristics* are

1 Swallowing—this is soon followed by retching if the airway is not removed
2 Eye signs—those of light anesthesia
3 Relaxation of muscles—incomplete

b Laryngeal—the apnea usually occurs when an intratracheal airway or other foreign body is inserted during light anesthesia *Characteristics* are

1 Eye reflexes, indicate light anesthesia
2 Expiratory apnea usually present, opposing attempts at insufflation
3 Possible presence of swallowing movements
4 Incomplete relaxation of muscles

c Traction—an apnea usually accompanies stimulation and traction of the mesentery, celiac plexus, gallbladder, pelvic organs, pleura, hila of the lungs, bronchi, esophagus, rectum, and other viscera inervated by the autonomic nervous system General *characteristics* are

1 Abrupt onset—immediately follows stimulation of visceral structures and persists as long as stimulation is continued
2 Accompanied by laryngeal spasm
3 Light anesthesia indicated by eye reflexes and signs
4 Inflation and deflation of thorax frequently accompanied by phonation

d Periosteal—similar to traction reflexes in most regards

e Carotid body—anoxia acts upon carotid body to reflexly stimulate respiration The stimulation is removed by relief of anoxemia and temporary apnea results The apnea lasts a brief interval—15-20 seconds, as a rule The *characteristics* are

1 Dilated pupils return to normal—other eye signs become active
2 Cyanosis, if present, quickly disappears
3 Blood pressure is elevated, pulse is slow

f Hering Breuer—apnea is caused by forceful mechanical overdistension of the alveoli *Characteristics* are

1 Well maintained circulation
2 Eye reflexes active—indicate surgical planes of anesthesia

6 Complete obstruction of the airway

a Thorax cannot be inflated or is inflated only with difficulty
b Pupils dilated from anoxia
c Cyanosis usually present
d Blood pressure elevated, pulse slowed at first
e Immediate relief by inserting airway change of position, suctioning of secretions, etc

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CIRCULATORY COMPLICATIONS

Circulatory complications during anesthesia are manifested by alterations in the rate and character of the pulse, an elevation or depression of the blood pressure, and changes in pulse pressure Circulatory changes are intimately connected with respiratory and neurological complications Commonly encountered circulatory complications and their symptoms are

TACHYCARDIA

Definition A rapid pulse rate

Causes

1 Excitement during induction of anesthesia
2 Blood loss, shock, or trauma during surgery
3 Atropine used for premedication (particularly in children)
4 Effect of anesthetic drugs upon the conducting tissue of the heart A shift of the pacemaker and arrhythmias result (cyclopropane)
5 Effect of sympatheticomimetic amines used in conjunction with anesthesia
6 Hyperthyroidism
7 Sympathomimetic effects of anesthetic drugs

BRADYCARDIA

Definition A slow pulse rate

Causes

1 Sinus bradycardia
2 Asphyxia or anoxemia accompanying respiratory failure
3 Increased irritability of conducting tissues of the heart with shift of the pacemaker to the auriculo-ventricular node or to the ventricle

similar noises accompanying inspiration and expiration The vocal cords are only partially approximated

Complete spasm Apnea and inability to inflate the thorax The vocal cords are completely approximated

Causes

1 Secretions in the larynx Mucus, blood, vomitus, and other secretions on the vocal cords initiate the spasm This is perhaps the most frequent cause
2 Irritations of the membranes of the larynx High concentrations of anesthetic drugs, particularly ether, cause spasms Soda lime dust, particularly in the to and fro canister, is caustic in action and irritates mucous membranes
3 Mechanical stimulation Trauma from airways, laryngoscopes, suction tips, and other foreign bodies also cause spasm This is most frequent after attempted intubations
4 Carbon dioxide excess See hypercapnia (page 224)
5 Reflex stimulation Traction on the gallbladder, stomach, spleen, mesentery, and trachea, rectal dilatation, vaginal, perineal, and periosteal stimulation cause adductor spasm of cords and jerky respiration
6 Autonomic nervous system effects Parasympathetic stimulation or sympathetic depression from drugs Cyclopropane and pentothal are most common offenders
7 Anoxia Spasm of all muscles including those of the vocal cords frequently accompanies mild anoxemia

Treatment Incomplete Spasm

1 Increase the oxygen in the inhaler
2 Aspirate secretions from the pharynx using metal suction tip
3 Insert an artificial (pharyngeal) airway if one is not already in place
4 Inflate the inhaler with oxygen so that a positive pressure of approximately 10 cm H_2O is attained
5 Inspect or replace soda lime or check patency of exhalation valve to rule out carbon dioxide excess
6 Insert an intratracheal catheter if these measures do not readily relieve the obstruction
7 Use succinyl choline to facilitate intubation

Treatment Complete Spasm

1 Attempt to inflate the thorax with mask and bag using positive pressure A small amount of oxygen frequently relieves the anoxia and causes the spasm to "break" Compression of thorax may cause slight abduction of cords to facilitate this
2 Perform intratracheal intubation

6 Use drugs which reduce cardiac irritability such as procaine, procaine amide or quinidine intravenously or apply procaine to surface

Comment Most arrhythmias during anesthesia can be diagnosed by palpation of the pulse, but some can be detected only by use of the electrocardiograph

Hypotension with Decreased Pulse Pressure and Tachycardia (Fig 76)

Causes

1 Shock from trauma, hemorrhage, toxemia, etc
2 Deep anesthesia or overdosage

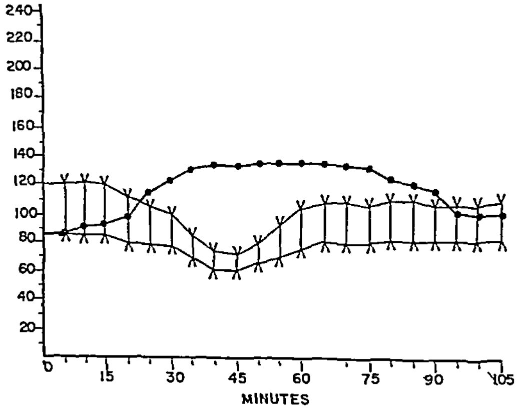

Fig 76 Hypotension accompanied by tachycardia and decreased pulse pressure (Traumatic shock hemorrhage etc.)

3 Cardiac failure from decompensation, coronary infarction, and other diseases of the heart

Management

1 Lighten anesthesia or discard inhaled mixture completely and replace with oxygen
2 Administer plasma volume expanders and blood if due to shock
3 Treat for cardiac failure if due to this cause

4 Epinephrine used in conjunction with anesthetic drugs which increase cardiac irritability
5 Vagal stimulation in thoracic and other types of surgery in which the vagus nerves are exposed
6 Development of heart block in cardiac patients
7 Myocardial depression from cardiotoxic drugs (chloroform, local anesthesia)
8 Sympathetic depression with vagal predominance (spinal anesthesia)

ARRHYTHMIAS DURING ANESTHESIA

An arrhythmia is a disturbance of the normal rhythm of the heart The types of arrhythmias which occur during anesthesia vary considerably Many can be diagnosed by palpation of the pulse, others require the use of the electrocardiograph

Causes

1 Respiratory depression resulting in anoxia or carbon dioxide excess
2 Effects of epinephrine and other vasopressors used in conjunction with anesthetic drugs
3 Increase in cardiac irritability caused by the anesthetic drugs Chloro form, cyclopropane, ethyl chloride may cause them Less frequently other agents are responsible
4 Autonomic effects due to stimulation of structures such as the carotid sinus, aortic plexus, hilum of the lungs, trachea, bronchi, etc
5 Deep anesthesia from the anesthetic agent, particularly cyclopropane or chloroform
6 Effects of the anesthetic and the surgical procedure upon pre-existing cardiac disease
7 Direct stimulation of the heart during intrathoracic manipulation
8 Electrolyte disturbances such as excess or deficiency in potassium ion

Diagnosis

Most arrhythmias during anesthesia can be diagnosed by palpating the pulse, but some can be detected only by use of the electrocardiograph

Treatment

1 If due to deep anesthesia add oxygen to lighten it and rule out anoxia
2 Inspect the carbon dioxide absorber to rule out carbon dioxide excess
3 Shift to another anesthetic agent if due to the agent and persists
4 Cease offending stimulation if due to surgical manipulation or block area with procaine
5 Investigate electrolyte balance

6 Use drugs which reduce cardiac irritability such as procaine, procaine amide or quinidine intravenously or apply procaine to surface

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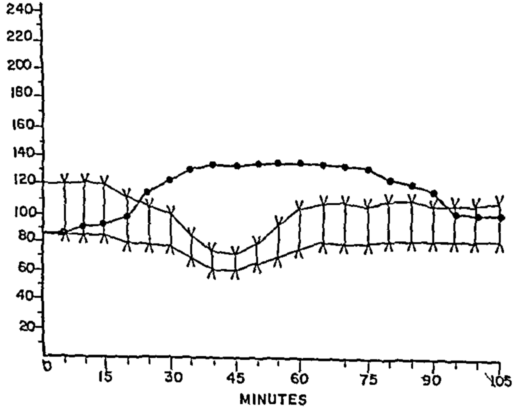

Fig 76 Hypotension accompanied by tachycardia and decreased pulse pressure (Traumatic shock hemorrhage etc)

3 Cardiac failure from decompensation, coronary infarction, and other diseases of the heart

Management

1 Lighten anesthesia or discard inhaled mixture completely and replace with oxygen
2 Administer plasma volume expanders and blood if due to shock
3 Treat for cardiac failure if due to this cause

Hypotension with Decreased Pulse Pressure and Bradycardia (Fig 77)

Causes

1 Anoxia with deep anesthesia
2 Spinal anesthesia
3 Reflex stimulation due to traction on viscera, mesentery, or other structures
4 Local anesthetic drug toxicity during general anesthesia

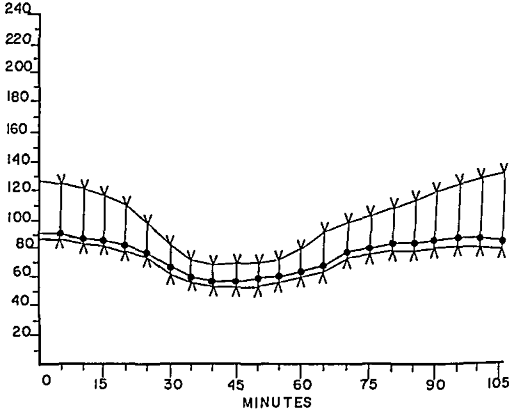

Fig 77 Hypotension accompanied by a relatively slow pulse or bradycarpia and decrease in pulse pressure (Anoxia primary shock, heart block etc)

5 Transfusion reaction due to incompatible blood
6 Over premedication
7 Awkward position or positional changes

Treatment

1 100% oxygen by mask if due to anoxia
2 Ephedrine 25 mgm I V or similar acting vasopressor if due to reflex activity, spinal anesthesia or over premedication
3 Procaine block of pathways from site of offending stimulus

Hypertension with Slight or No Change in Pulse Rate (Fig 78)

Causes

1 Carbon dioxide excess

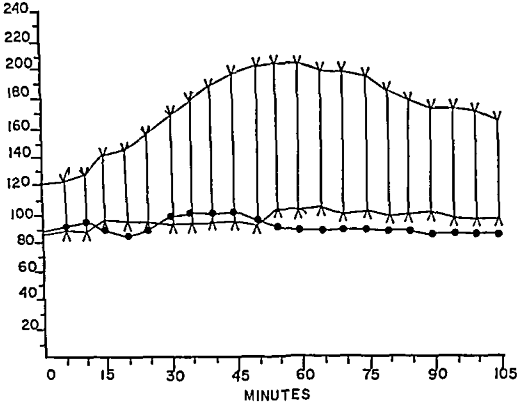

FIG 78 Hypertension accompanied by relatively little change in pulse rate CO_2 excess

2 Cyclopropane anesthesia
3 Bad posture during anesthesia
4 Inadequate ventilation due to depressant drugs
5 Intracranial lesions
6 Stimulation during light anesthesia

Treatment

1 Assist or control respirations to remove excess carbon dioxide
2 Correct defective posture
3 Deepen anesthesia if light

Hypertension with Increase in Pulse Pressure and Tachycardia (Fig 79)

Causes

1 Anoxia, asphyxia
2 Use of epinephrine and related drugs

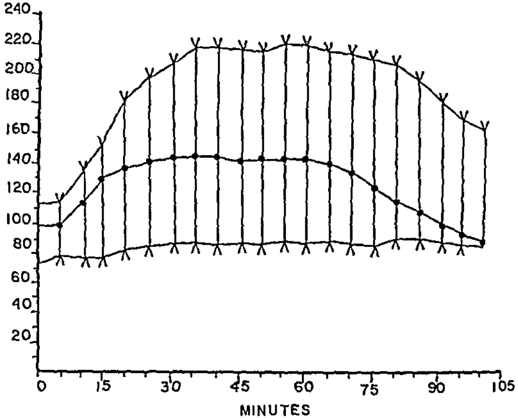

FIG 79 Hypertension accompanied by tachycardia (Thyrotoxicosis excitement during induction etc)

3 Cyclopropane anesthesia
4 Thyrotoxicosis
5 Prolonged excitement period

Treatment

1 Oxygenate patient
2 Lighten anesthesia if deep
3 Change agents if due to cyclopropane and lightening does not correct
4 Discontinue surgery if tachycardia is unmanageable and severe (thyrotoxicosis)

HYPERTENSION WITH INCREASE IN PULSE PRESSURE AND BRADYCARDIA (Fig 80)

Causes

1 Increase in intracranial pressure
2 Cyclopropane anesthesia
3 Anoxia accompanying anesthesia

Treatment

1 Ventilate patient if (due to anoxia) with adequate oxygen

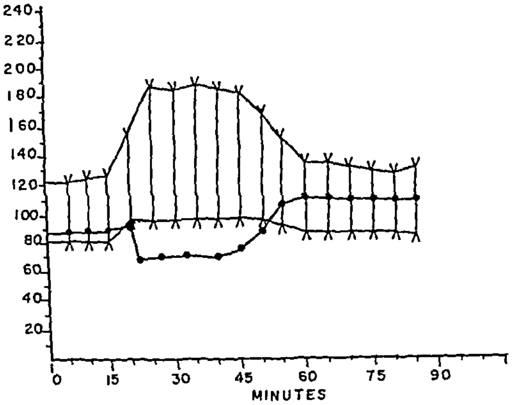

FIG 80 Hypertension accompanied by bradycardia Anoxia or cyclopropane anesthesia with respiratory depression

2 Lighten anesthesia
3 Correct cause of increased intracranial pressure

Cardiac Arrest and Massage

Definition Resumption of the circulation by massaging a heart which has ceased to effectively propel blood through the vascular bed

Purpose

1 To reinstate the heart beat to its normal state
2 To prevent the tissues, particularly those of the central nervous system from being deprived of oxygenated blood and nutritive substance

Types of Cardiac Arrest

1 Asystole or complete stoppage
2 Feeble cardiac contractions which are not detectable
3 Ventricular fibrillation

Causes of Cardiac Arrest on Operating Table

1 Anoxia or asphyxia
2 Overdosage of anesthetic drugs
3 Respiratory acidosis due to hypoventilation

4 Increased cardiac irritability from thyrotoxicosis or drugs such as cyclopropane, chloroform, ethyl chloride
5 Vagovagal reflexes in presence of hypoventilation

Diagnosis (with Chest Closed)

1 Absence of heart sounds
2 Absence of pulsation in the major vessels (if abdomen is open or artery is exposed)

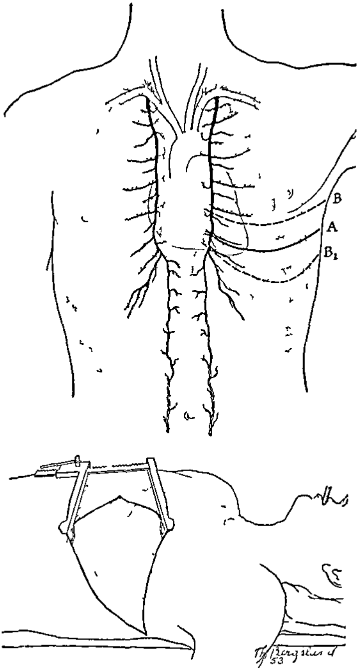

FIG 81 To expose the heart the chest wall is incised on the left side between the fourth and fifth ribs from the parasternal area to the midaxillary line and the ribs spread apart Care is taken to avoid the internal mammary vessels (Courtesy Robert Hosler Cardiac Resuscitation Springfield Thomas, 1954)

3 Absence of pulsation in the retinal vessels
4 Absence of capillary refill

Treatment of Asystole

A Materials—(a) Scalpel
(b) Rib spreader

B Procedure

1 Ventilate the lungs with 100% oxygen using any effective method of artificial respiration which is immediately available
2 Perform cardiac massage as follows
(a) Quickly prepare the skin with an adequate sterilizer (Omit if material is not immediately available)
(b) Incise the chest in the fourth left interspace from sternum to posterior axillary line Divide fourth and fifth costal cartilages and spread the ribs apart (Fig 81)
(c) Grasp the heart in the cup shaped right hand and compress as rapidly as possible or until the arterial pressure is raised to 60 to 80 mm Hg (about 60X per minute)
(d) Every fifth beat compress the aorta beyond the coronary vessels in order to increase coronary blood flow

Comment	*Reason*
1 Maintain a rate as close to 60 as possible	A more rapid rate is difficult to maintain Too slow a rate results in ineffective circulation
2 Have an assistant "scrub in"	One operator easily tires, particularly in protracted cases
3 Do not waste time establishing a diagnosis with stethoscope or E K G	It is best to err on the side of open ing chest and finding a beating heart than to delay and have a decerebrate patient
4 Institute an arterial transfusion if blood pressure is not maintained at 60 mm Hg or more	The coronary arteries are perfused and an effective head of pressure is maintained to nourish tissues
5 Use gentleness in compressing the heart	The myocardium may be traumatized Perforation may occur
6 Inject 1–2 cc 1/2% barium chloride solution into the right auricle if ventricles are atonic	Barium chloride increases tone of cardiac muscle
7 Do not use epinephrine in the presence of drugs which increase myocardial irritability, such as cyclopropane, chloroform or ethyl chloride	Asystole may be converted to fibrillation which is more difficult to treat
8 Inject only 1/4 cc of 1–1000	This confines the stimulus, me-

solution of epinephrine, when used, into the right auricle	chanical or chemical to the part of the heart in which fibrillation is of lesser importance or consequence
9 Do not be misled by the E K G in making a diagnosis	A current may still be generated by the heart and a tracing obtained even though the heart is not effectively propelling blood
10 *Open the pericardium if massage is difficult*	The heart may be grasped more effectively if the pericardium is open
11 Do not extend the incision too close to the sternum	The internal mammary vessels may be cut Bleeding may occur after resuscitation

Management of Ventricular Fibrillation

Ventricular fibrillation is characterized by absence of signs of cardiac activity, no pulse and no blood pressure Although it appears to come on abruptly four pre ventricular fibrillation stages are recognized, as follows

Stage I The undulatory stage which lasts from one to two seconds

Stage II Convulsive incoordination which lasts from 15 to 40 seconds Contractions are more frequent and involves smaller areas of the ventricular muscles

Stage III A tremulous incoordination which lasts from two to three minutes The surface of the muscle is broken up into independently contracting areas of a never increasing size which are in a phase with each other The ventricles appeared to be tremulous

Stage IV Final stage Atonic fibrillation develops when anoxia of the cardiac muscle weakens its contractile force This stage usually occurs 2 to 5 minutes following the first stage and is marked by weak contractions of wavelets Object is to defibrillate individual isolated areas into larger ones by repeated electrical shocks then stop entire fibrillation with a final shock

Treatment of Defibrillation

A Materials—(a) Defibrillator
(b) Scalpel and rib spreader

B Procedure

1 Open chest in same manner described for asystole
2 Massage the heart in same manner as for asystole for 30 to 60 seconds with compression of the aorta distal to the coronaries to provide blood to the myocardium
3 Apply each electrode of the defibrillator to each side of the heart (Use 60 cycle 110 volt current with a resistance sufficient to allow an average of 1 to $1\frac{1}{2}$ amperes to pass through the heart) (Fig 82, 83)

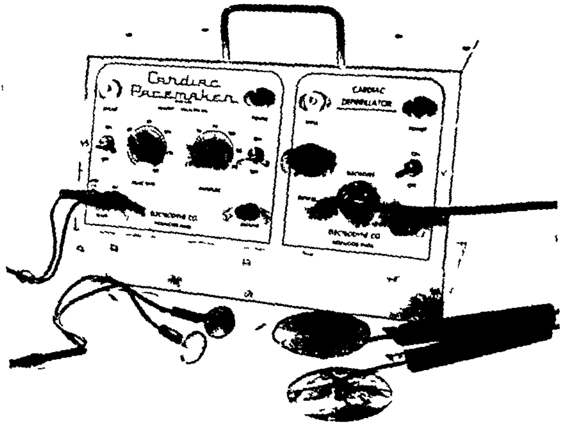

FIG 82 Combination cardiac pacemaker and defibrillator The small electrodes of the pacemaker are applied to the chest wall to send rhythmic electrical impulses into the heart to re establish normal rhythm. The broad electrodes of the defibrillator are applied directly to the surface of the heart when ventricular fibrillation has occurred (Courtesy Electrodyne Company)

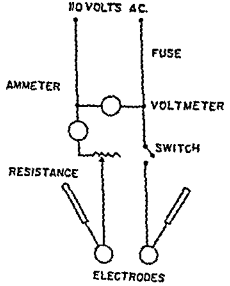

FIG 83 Wiring diagram of defibrillator using 110 volt alternating current

4 Shock the heart for 1/10 of a second at one to two second intervals until fibrillation disappears The heart will then be in asystole Three to 7 shocks are usually necessary
5 Manipulate as for asystole

Comment	*Reason*
1 Do not use epinephrine in the face of ventricular fibrillation	Cardiac irritability is present The drug further enhances it
2 Cold isotonic saline solution at 0°C may be poured over the heart during the period of electric shock	Cold reduces cardiac irritability May be used if defibrillator is not available
3 Inject one to two cc barium chloride into myocardium if it is atonic	Barium chloride increases the tone of the heart muscle
4 Do not use digitalis or related glucosides	It is felt that they increase myocardial irritability
5 Do not attempt defibrillation without opening the chest	No drug is satisfactory to defibrillate the heart
6 Expect skeletal muscles to contract with each shock	The current spreads throughout the body
7 Apply procaine 1% to the surface of heart or into pericardium when marked irritability exists	Procaine decreases cardiac irritability

Adjunctive Therapy to Cardiac Resuscitation

1 Aspirate the pharynx, trachea and bronchi to maintain a free airway
2 Administer antibiotics to reduce the incidence of pulmonary and wound infection
3 Turn patient frequently in post recovery period to avoid hypostatic congestion
4 Maintain adequate fluid balance, checking both blood volume and hematocrit
5 Maintain artificial or assisted respiration if apnea or ineffective respiration is present

Prognosis of Cardiac Resuscitation

1 Variable—depends upon the time therapy is instituted after arrest and the nature of the disease present The sooner the heart is resuscitated the more likely it is to revive
2 Patients developing arrest who have chronic illness are revived more easily than those who have acute infections
3 Hearts of individuals with chronic tuberculosis are revived more easily than those of subjects with other diseases
4 Hearts of children are more responsive than those of adults

FIG 84 When attempting to re establish the beat the heart is held between the palms of the hands and compressed rhythmically 80 times per minute or as rapidly as necessary to maintain an adequate head of blood pressure The fingers of the left hand surround the left ventricle and the thumb lies across the right ventricle When two hands are used the flat of each hand is placed over each ventricle flushing and compression is made towards the intra ventricular septum (Courtesy Robert Hosler, Cardiac Resuscitation Springfield Thomas 1954)

5 Hearts of patients with heart disease respond with greater difficulty than those of patients who have normal hearts
6 Hearts of patients with congenital defects revive easier than those who have organic disease
7 Hearts of patients with chronic emphysema revive more easily than those who have normal pulmonary function
8 Spontaneous respiratory activity appears within 5 to 30 minutes after regular rhythm and blood pressure are restored
9 Chances of recovery are good if period of circulatory stasis does not exceed 2 to 3 minutes
10 Anesthesia increases the resistance to anoxia probably by depressing cellular activity and reducing CO_2 output and O_2 demand
11 Recovery is more common after asystole than fibrillation

Performing Cardiac Massage With the Chest Closed When the Abdomen is Open

Purpose To massage the heart without opening the thorax

1 Introduce gloved hand to the left upper quadrant behind the diaphragm lateral to the liver
2 Compress the heart against anterior chest wall by compressing the diaphragm anteriorly Repeat 30 to 60 times a minute with thorax open If fibrillation is present open thorax

Comment

1 This is a substitute and is not as effective as opening the thorax but may be used as temporary expedient until chest is opened
2 This maneuver cannot be used for ventricular fibrillation
3 This is ineffective for giving intracardiac injections of various drugs
4 If hiatus hernia is present, maintain massage through it
5 Maintain massage until heart no longer shows any evidence of contracting in cases of failure to respond

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NEUROLOGICAL COMPLICATIONS

Neurological complications are the result of some undue stimulation of the nervous system Disturbances of the autonomic nervous system are usually

manifested by changes in the circulatory and respiratory systems and are therefore described under those headings Disturbances of the central nervous system are manifested by increased muscular activity, rigidity, and convulsions

Convulsions Under Anesthesia

Definition Convulsions are involuntary muscle contractions They are manifestations of increased irritability of cortical and other cells which control motor function

Causes

1 Asphyxia from any cause
2 Hypercapnia
3 Awkward positions—lithotomy, lateral, prone, kidney, etc, caused by pressure or stretching of nerves
4 Overdosage of local anesthetic drugs used in conjunction with anesthesia (see regional anesthesia)
5 Stimulation of motor centers by such anesthetic drugs as evipal and vinethene
6 Preexisting pathological changes in the nervous system not related to anesthesia (brain tumor, epilepsy, meningitis)
7 Idiopathic—cause not determined Often called "ether convulsions"
8 Tetany from hyperventilation

Convulsions Due to Asphyxia

Features

1 They accompany obvious asphyxia with its attendant signs and symptoms, such as cyanosis, sweating, bradycardia, etc
2 Convulsions are spasmodic, begin in the small muscles as twitchings, but gradually involve the larger muscles
3 Are obtunded by anesthesia

Treatment

1 Reestablish the airway and relieve anoxemia immediately
2 Administer ultra short acting barbiturates, such as evipal or pentothal, intravenously if convulsions persist
3 Reduce body temperature if elevated

Convulsions Due to Carbon Dioxide Excess

Features

1 They accompany rebreathing or the inhalation of high concentrations of carbon dioxide (15% or more)
2 Small muscles begin to twitch at first and gradually activity spreads to larger muscles

Treatment

1 Administer oxygen by means of a small mask or nasal catheter
2 Eliminate all rebreathing
3 Confirm the identity of all gases on the machine
4 Use anticonvulsants (pentothal, surital) to control if they do not disappear

Idiopathic (Ether) Convulsions

Causes Their etiology remains unknown Many theories regarding their possible cause have been advanced Among the most prominent are

Hypercapnia
Alkalosis
Acidosis
Hypocalcemia
Disturbed carbohydrate metabolism
Neurotoxin liberated during anesthesia
Impure air or oxygen
Overdose of atropine
Overoxygenation

Features

1 They most frequently are seen in youthful patients or children
2 They accompany "toxic" or septic conditions
3 They occur under deep anesthesia and are not relieved by lightening or deepening anesthesia
4 They occur with ether anesthesia but can occur with other agents
5 *They are often accompanied by an elevation of body temperature*
6 They are more frequent when environment is hot
7 They become worse as anesthesia deepens
8 They are not related to impurities in ether
9 They are generalized and not confined to any one part of the body
10 They develop after the anesthesia has been established for 20 or 30 minutes

Treatment

1 Discontinue anesthetic agent and discard inhaler
2 Reestablish the airway if it is not patent Intubate if necessary
3 Administer an ultra short-acting barbiturate slowly in amounts sufficient to control them
4 Administer alkalizing solutions (such as sodium lactate) intravenously
5 Administer oxygen by catheter or semi closed mask
6 Cool body with alcohol sponges or fan
7 Administer calcium salts intravenously (1 0 gm calcium gluconate)

Sequelae

1 If convulsions persist untreated, the patient ultimately succumbs from asphyxia and circulatory failure Hyperthermia supervenes (Temperature varies from 105°F to 110°F)
2 If convulsions are controlled early and effective treatment is instituted, the patient may recover

Comment	*Reasons*
1 Avoid any device which allows rebreathing or the accumulation of excess carbon dioxide in the inhaler	Recent data suggest hypercapnia as one of the factors predisposing to convulsions
2 Do not employ inhalers for the administration of oxygen during the treatment Use nasal catheter or nonrebreathing semi closed inhaler	The amount of carbon dioxide rebreathed in a small mask may disturb the biochemical mechanism involved
3 Cool body with current of air and alcohol sponges	Excessively high body temperature contributes to the nervous system damage
4 Empty breathing bag frequently if artificial respiration becomes necessary	Complete removal of all carbon dioxide in the inspired air is necessary

Convulsions Due to Vinyl Ether

Causes

Drug stimulates motor centers in spinal cord or brain

Features

1 Occur in unpremedicated subjects more often than medicated
2 Occur in children more often than adults
3 Occur during induction period of anesthesia
4 Occur in deep, prolonged anesthesia
5 Disappear when drug is discontinued
6 Not related to impurities in drug or to anoxia

Treatment

1 Discontinue drug—disappear as anesthesia lightens
2 Administer barbiturates intravenously (pentothal) if they persist

Localized Convulsions Due to Traction and Posture

Causes

Nerves placed on stretch or irritated by physical factors

Features

1 Are localized in one part of body—usually lower
2 Occur when patient is in awkward position—lithotomy, lateral, etc
3 Disappear with change in posture

Convulsions Due to Local Anesthetic Drugs

See Part VI, Regional Anesthesia

Emergence Delerium

Definition Delerium, excitement and struggling during recovery phase of anesthesia

Causes

1 Second stage anesthesia on recovery from slowly eliminated agents (ether)
2 Emergence from gas anesthesia which was combined with basal narcosis with non analgesic drugs such as barbiturates, avertin, scopolamine
3 Anoxia due to reduced vital capacity (after pneumonectomy, atelectasis, pneumothorax, etc)
4 Inadequate ventilation due to partial obstruction—secretions, laryngeal edema, compression of trachea due to hematomas, etc
5 Carbon dioxide excess following use of drugs which cause its retention—cyclopropane, pentothal
6 Rapid recovery from quickly eliminated anesthetic administered without premedication with narcotics (cyclopropane alone)
7 Chronic alcohol addict recovering from anesthesia

Treatment

1 If due to pain in presence of non analgesic basal narcotic—administer a narcotic such as morphine, Demerol or dilaudid and so on intravenously
2 If due to inadequate ventilation administer oxygen Morphine may also be required Use small doses

Generalized Shivering at Emergence

Causes

1 Patient recovering in cold environment Apply blankets and remove to warmer environment
2 Pyrogenic reaction due to fluid administered when patient was under anesthesia Temperature rises after chill—Apply blankets and sedate
3 Emergence after pentothal—Hyperventilate and sedate with phenobarbital parenterally

Hyperthermia

Description An elevation of body temperature above normal which may appear during operation or immediately postoperatively

Causes During Operation

1 Warm external environment
2 Drugs which cause diminished sweating—atropine
3 Aggravation of a pre existing fever
4 Heat added from closed system (To and Fro)
5 As a symptom of ether convulsions

Post Anesthesia

1 Aggravation of fever from systemic disease
2 Pyrogenic reaction caused by intravenous fluids
3 After intentional hypothermia—temperature over shoots mark on warming
4 After deep anesthesia in which subnormal temperature occurs—overshoots mark while recovering
5 Drugs which inhibit heat loss—atropine etc
6 Central damage from anoxia or CO_2 excess
7 Heat stroke, postoperative
8 Thyroid crisis
9 Dehydration

Treatment

1 External cooling with ice pack, alcohol or ice blanket

Comment

1 The heat regulatory center is inactivated by nervous system depressants The patient tends to assume the temperature of the external environment
2 Reduce temperature to several degrees above normal Then proceed gradually otherwise mark will be overshot

Reference

Cassels W H Becker T J, and Seevers, M H Convulsions During Anesthesia Anesthesiology, *1* 56 July 1940

Sweating During Anesthesia

Causes

1 Warm external environment or excessive coverings over the patient
2 Suboxygenation from obstruction, spasm, etc, during anesthesia, particularly ether
3 Administration of drugs which stimulate the sympathetic nervous system

Features

1 Are localized in one part of body—usually lower
2 Occur when patient is in awkward position—lithotomy, lateral, etc
3 Disappear with change in posture

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3 Administration of drugs which stimulate the sympathetic nervous system

TECHNICAL COMPLICATIONS

Technical complications arise from faulty or defective apparatus or improper manipulation of the equipment They usually result in inability to maintain a constant level of anesthesia, hypercapnia, or anoxia

Common technical difficulties encountered are

Excess Accumulation of Gas in the Inhaler

Symptoms

1 Overdistension of the breathing bag
2 Interference with satisfactory respiratory movements

Causes

1 The metabolic flow of oxygen is above body requirements
2 The seats of pin valves are worn and leak
3 The emergency oxygen valve is open slightly
4 Air is drawn in around the intratracheal catheter during inhalation and exhaled into the inhaler (see intratracheal anesthesia)

Leaks in the Inhaler

Leaks in the semi closed or closed system, whether large or small, should not be tolerated because they

1 Prevent the maintenance of constant level of anesthesia
2 Cause a costly loss of gases
3 Increase the fire hazard
4 Render the apparatus useless as an inhaler for artificial respiration in event of emergency or for positive pressure

Sources of Leaks in Closed Inhalers

1 Mask
   a It usually does not fit the face properly (see fitting masks, page 85)
   b It is not fastened properly
   c Slip joints are loose
2 Exhalation valve
   a The spring is defective
   b The valve is open
3 Canister
   a The seams are ruptured from careless handling
   b Washers and other connections are worn or missing
   c It is overfilled with soda lime and not tightly sealed
4 Rebreathing bags
   a Punctures and tears occur from fingernails or sharp instruments
   b The rubber is worn

5 Rubber tubes (Circle filters)
   a The joints at the filters or at the masks are loose from wear
   b Holes are present in tubing
6 Valves
   a Joints around valves are loose (circle filter)
   b Valves are loose and worn or stiff
7 Ether vaporizers
   a Jars are broken or loose or chipped about the lip
   b The vent on the dropper type is not closed
8 Flow meters
   a The top is not screwed tightly on the hydraulic meters
   b The valve for replacing water may be open
9 Delivery tube
   a The tube is old and worn
   b The tube is oversized and does not fit on sleeves
   c The tube is perforated

Comment

The majority of the leaks during anesthesia occur about the face piece

Emesis During Anesthesia

Definition The sudden expulsion of gastric contents through the esophagus into the pharynx The act is partly voluntary and partly involuntary

Causes of Emesis

1 During the induction period (stages I and II)
   a Difficult or prolonged induction from improper premedication, incorrect selection of agent or incorrect technique of administration
   b Full stomach from recently ingested food or liquids
   c The artificial airway is inserted into the pharynx prematurely and (in stages I and II) stimulates vomiting
   d Effect of opium alkaloids used for premedication upon the vomiting center
2 During the maintenance of anesthesia
   a The patient, through carelessness of the anesthetist, or because of technical difficulties, passes from stage III to stage II and the artificial airway or mucus in the pharynx reflexly initiates vomiting
3 During the recovery period
   a Central effect of drug acts on medulla and stimulates the vomiting center
   b Anoxia, regardless of the cause, is usually followed by vomiting
   c Artificial airway or secretions initiate vomiting when the pharyngeal reflex returns

d Surgical manipulations (handling of intestines, and stomach traction on the gallbladder) may be responsible

Treatment	*Reasons*
1 Lower the head either over the edge of the table or place the patient in the Trendelenburg position	The vomitus gravitates into the nasopharynx to minimize the possibility of aspiration into the larynx
2 Apply suction to the pharynx using metal pharyngeal suction tip (Fig 85)	This aids in rapid removal of solid particles and liquids Metal tip still permits suctioning should the patient bite

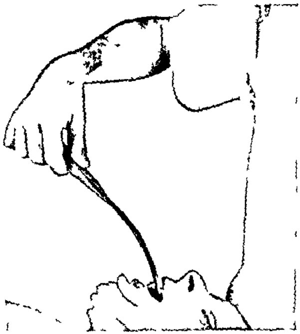

Fig 85 The management of emesis regurgitation or hypersecretion is accomplished by lowering the head and aspiration by mean of a metal pharyngeal tip attached to a suction apparatus

Prophylaxis	*Reasons*
1 Attempt as rapid an induction as possible—the zone of irritability of the vomiting center is passed quickly	The vomiting center is depressed in stage III, plane 1
2 Administer adequate premedication to patient at the proper time	This assures a smooth and rapid induction and minimizes anoxia due to obstruction or spasm
3 Remove the artificial airway before the patient recovers from surgical anesthesia	Stimulation of the pharynx and reflex vomiting are avoided
4 Withhold food and liquids by mouth for six to eight hours in patients scheduled for elective surgery	Patients tend to evacuate contents of a full stomach when they are recovering from anesthesia
5 Observe the patient carefully dur	Retching, particularly if an airway

ing maintenance phase of anesthesia and avoid passing from stage III to stage II	is in the pharynx, follows lightening of anesthesia
6 Omit opium alkaloids for premedication if a known idiosyncrasy to these drugs exists	Certain opium alkaloids excite the vomiting center

Dangers of Emesis

1 The acid nature of gastric contents causes them to be highly irritating to the laryngeal mucosa Spasm and obstruction result

2 Solid particles are aspirated into the respiratory tract Acute asphyxia and immediate death, bronchopneumonia (common), atelectasis of one or more lobes, or peripheral circulatory failure, are the usual sequelae of such accidents

Comment	*Reasons*
1 Remember that nausea and emesis and its sequelae may accompany or follow any type of anesthesia, whether inhalation, intravenous, rectal, or regional	The initiation of the vomiting reflex is of central origin and occurs when non volatile as well as volatile anesthetic drugs are employed
2 Be prepared for emesis in patients known to have full stomachs	The vomiting reflex is easily excited when the stomach is full
3 Remember that a patient may vomit food even though he has been fasting	The emptying time of the stomach is usually retarded in the preoperative period in many subjects, possibly the result of psychic stimulation
4 Remember that asphyxia from aspiration is a frequent cause of sudden death on the operating table	There is no effective treatment for this accident when it occurs

A suction apparatus should be available in every operating room for the exclusive use of the anesthetist

Management of Regurgitation During Anesthesia

Definition The sudden expulsion of gastric or intestinal contents into the oropharynx during surgical anesthesia The act is purely involuntary and occurs during the surgical stage of anesthesia Regurgitation differs from emesis in that emesis is a partly voluntary act which occurs in stage II of anesthesia

Causes of Regurgitation

1 Relaxation of the cardiac sphincter releases the contents of a dilated stomach into the esophagus

d Surgical manipulations (handling of intestines, and stomach traction on the gallbladder) may be responsible

Treatment	*Reasons*
1 Lower the head either over the edge of the table or place the patient in the Trendelenburg position	The vomitus gravitates into the nasopharynx to minimize the possibility of aspiration into the larynx
2 Apply suction to the pharynx using metal pharyngeal suction tip (Fig 85)	This aids in rapid removal of solid particles and liquids Metal tip still permits suctioning should the patient bite

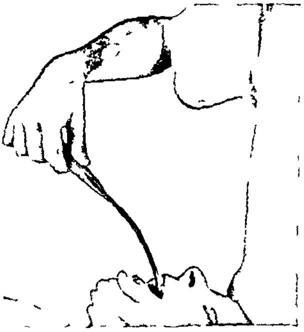

FIG 85 The management of emesis regurgitation or hypersecretion is accomplished by lowering the head and aspiration by means of a metal pharyngeal tip attached to a suction apparatus

Prophylaxis	*Reasons*
1 Attempt as rapid an induction as possible—the zone of irritability of the vomiting center is passed quickly	The vomiting center is depressed in stage III, plane 1
2 Administer adequate premedication to patient at the proper time	This assures a smooth and rapid induction and minimizes anoxia due to obstruction or spasm
3 Remove the artificial airway before the patient recovers from surgical anesthesia	Stimulation of the pharynx and reflex vomiting are avoided
4 Withhold food and liquids by mouth for six to eight hours in patients scheduled for elective surgery	Patients tend to evacuate contents of a full stomach when they are recovering from anesthesia
5 Observe the patient carefully dur	Retching, particularly if an airway

ing maintenance phase of anesthesia and avoid passing from stage III to stage II	is in the pharynx, follows lightening of anesthesia
6 Omit opium alkaloids for premedication if a known idiosyncrasy to these drugs exists	Certain opium alkaloids excite the vomiting center

Dangers of Emesis

1 The acid nature of gastric contents causes them to be highly irritating to the laryngeal mucosa Spasm and obstruction result

2 Solid particles are aspirated into the respiratory tract Acute asphyxia and immediate death, bronchopneumonia (common), atelectasis of one or more lobes, or peripheral circulatory failure, are the usual sequelae of such accidents

Comment	*Reasons*
1 Remember that nausea and emesis and its sequelae may accompany or follow any type of anesthesia, whether inhalation, intravenous, rectal, or regional	The initiation of the vomiting reflex is of central origin and occurs when non volatile as well as volatile anesthetic drugs are employed
2 Be prepared for emesis in patients known to have full stomachs	The vomiting reflex is easily excited when the stomach is full
3 Remember that a patient may vomit food even though he has been fasting	The emptying time of the stomach is usually retarded in the preoperative period in many subjects, possibly the result of psychic stimulation
4 Remember that asphyxia from aspiration is a frequent cause of sudden death on the operating table	There is no effective treatment for this accident when it occurs

A suction apparatus should be available in every operating room for the exclusive use of the anesthetist

Management of Regurgitation During Anesthesia

Definition The sudden expulsion of gastric or intestinal contents into the oropharynx during surgical anesthesia The act is purely involuntary and occurs during the surgical stage of anesthesia Regurgitation differs from emesis in that emesis is a partly voluntary act which occurs in stage II of anesthesia

Causes of Regurgitation

1 Relaxation of the cardiac sphincter releases the contents of a dilated stomach into the esophagus

2 Manipulation of upper gastrointestinal tract forces fluid or solid materials into the pharynx This is frequently a complication of pyloric or high intestinal obstruction, gastric hemorrhage, or dilatation

Treatment The same as for emesis

Prophylaxis

1 Insert a stomach tube and decompress the stomach before induction of anesthesia in all patients undergoing gastric surgery or suspected of having intestinal obstruction
2 Allow the stomach tube to remain in place and allow continuous drainage during anesthesia
3 Anesthetize patients undergoing gastric surgery as quickly as possible and insert an orotracheal catheter equipped with inflatable cuff to seal trachea from pharynx

Sequelae

1 The patient usually drowns in his own secretions unless suction is applied quickly
2 "Aspiration" pneumonia may follow if patient survives the sudden circulatory failure and the asphyxia which result from this accident
3 *Severe laryngeal spasm results which may cause acute asphyxia*

Fires and Explosions

Definition

1 A *fire* results when a combustible substance presents a small area of its total bulk to oxygen and oxidation occurs at a limited zone Example, ether in a beaker burns
2 *An explosion results when an inflammable gas or vapor intimately* mixed with air or oxygen becomes ignited Combustion occurs so rapidly that the products of oxidation form almost instantly and expand with destructive violence

Drugs Which Are Inflammable

1) Ether 2) Vinethene 3) Ethyl chloride
4) Ethylene 5) Cyclopropane

Any of the above in the gaseous or vapor form mixed with nitrous oxide air, or oxygen form explosive mixtures

Drugs or Gases Which Are Non-Inflammable

1) Nitrogen 2) Carbon dioxide 3) Helium 4) Oxygen
5) Chloroform 6) Trichlorethylene 7) Nitrous oxide

Sources of Ignition in the Operating Rooms

1 *Flames* pipes, cigars, cigarettes, alcohol, gas lamps, etc

2 *Electrical Equipment* motors, heaters, x ray equipment, cauteries, switches, endoscopes, lamps, etc
3 *Static Electricity* friction from blankets, rubber goods, clothing, personnel moving about room, tearing of adhesive, shuffling of feet, etc
4 *Clicking Together of Metal Parts* slip joints, sleeves, etc
5 *Spontaneous Combustion* impure anesthetic agents

Precautions Pertaining to Selection of Agents

1 Do not use cyclopropane, ethylene, ether, or vinethene when the cautery, electrosurgical unit, electric saw, portable x ray or fluoroscope is used in any operating room
2 Do not use inflammable gases or vapors in wards or other divisions of the hospital not protected by sparkproof electrical equipment, conductive flooring, and proper humidification
3 Employ the closed system with carbon dioxide absorption wherever possible

Precautions Pertaining to Operating Room Personnel	*Reasons*
1 Do not allow operating room personnel to wear shoes with combined rubber soles and heels All shoes should be tested for conductivity periodically (Fig 88)	Such individuals may acquire electrostatic charges A spark may result if they touch the anesthetist, machine, or other apparatus which is positively charged
2 Do not allow operating room personnel to wear silk, rayon, or woolen garments	Such garments favor the accumulation of electrostatic charges
3 Do not allow smoking in the operating room suite	The temperature of open flames is above the ignition temperature of anesthetic mixtures
4 Do not allow visitors, nurses, or doctors to touch the anesthetist or the anesthesia apparatus at any time while surgery is in progress	They may have acquired an electrical charge opposite to that of the field A spark results when the potential is equalized
5 Do not unroll or tear adhesive in the vicinity of an anesthesia apparatus	The friction causes an electrostatic discharge and formation of sparks
6 Do not use non sparkproof plugs or electrical connections unless placed five feet from floor	A spark results in the switch when the electrical circuit is opened or closed
7 Do not use lamps with open sockets in the operating room	A spark results in the socket switch when the light is turned on or off
8 Do not use ether for cleaning purposes	Ether vapor is inflammable and may be ignited by friction
9 Avoid using nonconductive rub-	The covering prevents the static

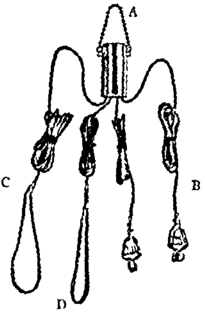

FIG 86 The Horton intercoupler

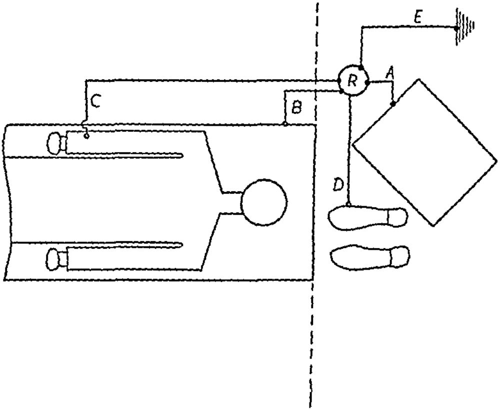

FIG 87 Schematic diagram of the hook up of the intercoupler (R) is a resistance of one megohm connected to the various leads Lead (A) is connected to the machine (B) to the operating table the wrist band of lead (C) is wrapped around the wrist of the patient (D) is wrapped around the left wrist of the anesthetist and (E) is clipped to the ground

ber pads or pillows If they must be used, cover them with a sheet, and do not remove cover during operation	electricity which results from friction
10 Do not use pails, buckets, and other mobile metal equipment which are not protected by rubber guards	The protection prevents the formation of sparks by the striking of metal on metal

Precautions To Be Observed by Anesthetists	*Reasons*
1 Do not move about the room and break contact with the patient	A difference in electrical potential between the anesthetist and the patient may develop
2 Install an intercoupler (fig 86) on all cases in which ether, cyclopropane, ethylene, or other inflammable gases or vapors are employed in room with nonconductive floor	This device allows an equalization of potentials between each unit of the anesthetic field
3 Maintain a relative humidity above 65% in the operating room	A high relative humidity aids in dissipation of electrostatic charges and minimizes the tendency toward explosions
4 Do not use electrical equipment which is not of sparkproof design	The operation of motors is accompanied by the formation of sparks
5 Be certain that all stretchers, stools, tables, etc, have bronze drag chains in contact with the floor	Bronze is an excellent conductor of electricity and does not produce sparks when it strikes tile or metallic substances
6 Use conductive rubber wherever possible	"Ordinary" rubber is a poor conductor of electricity and favors the accumulation of electrostatic charges in the inhaler
7 Do not cover anesthesia machines with drapes or sheets while they are idle	An electrostatic charge may accumulate and cause a spark when the drape brushes over the apparatus when it is removed
8 Do not jerk connections or slip joints apart during anesthesia	Sparks may form when metal pieces strike each other
9 Moisten the breathing bag and rubber tubes before commencing anesthesia Rinse after anesthesia is ended	Moisture aids in dissipation and neutralization of electrostatic charges
10 Use *pure drugs* at all times	Impure gases and vapors may have a lower flash point than the pure products

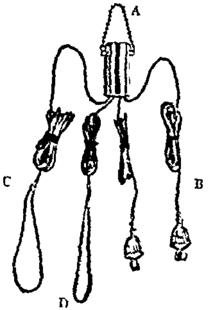

Fig 86 The Horton intercoupler

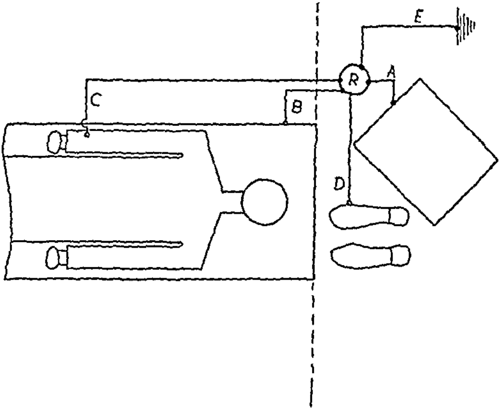

Fig 87 Schematic diagram of the "hook up" of the intercoupler (R) is a resistance of one megohm connected to the various leads Lead (A) is connected to the machine (B) to the operating table the wrist band of lead (C) is wrapped around the wrist of the patient (D) is wrapped around the left wrist of the anesthetist and (E) is clipped to the ground

11 Never lubricate any valve or gauge used on high pressure cylinders with oil or grease	High pressure atomizes grease and forms an explosive mixture
12 Always secure as snug a fit as possible at the mask to avoid leaks	Escaping vapors are easily ignited
13 Do not commence to flow inflammable gases from supply source into apparatus unless the mask is secure on the patient's face	This prevents the escape of inflammable mixtures into the room
14 Always close reducing valves when opening the main valve of a high pressure cylinder	The high pressure may suddenly be transmitted to the inhaler if the valve of any high pressure cylinder is opened without first closing the reducing valve
15 Protect all upright cylinders from toppling over	Valve may break off and the contents which are under high pressure escape with explosive violence
16 Turn off the flow of all gases and inflammable vapors when inserting airways Close obturator on the mask	Precautions to prevent the escape of inflammable mixtures into the room should be taken at all times
17 Do not remove the breathing bag from the inhaler during anesthesia	A difference in potential may develop and cause a spark to form when bag is replaced
18 Use cotton blankets to cover the patient while he is in the operating room	Wool is an excellent electrostatic generator and loses its charge to the air only if the relative humidity is very high (80–95%)

The Intercoupler

Description The intercoupler is an electrical unit composed of a resistance of one megohm (one million ohms) connected to five leads which act as conductors The resistance acts as a central connecting pair for the leads, is insulated, and is contained in a metal cylinder One lead is attached to a hook which acts as a hanger for the device The other four leads are insulated wires approximately six feet long, two of which terminate as clips and two as wristbands (Fig 87) The intercoupler is used when nonconductive flooring is not available in the operating room

Purpose The intercoupler allows equalization of the electrical potential between the patient, anesthetist, anesthesia apparatus, and operating table It thus prevents the occurrence of electrostatic sparks between members of the electrically connected group (Fig 86)

To Connect

1 Fasten one clip to an unpainted portion beneath the operating table

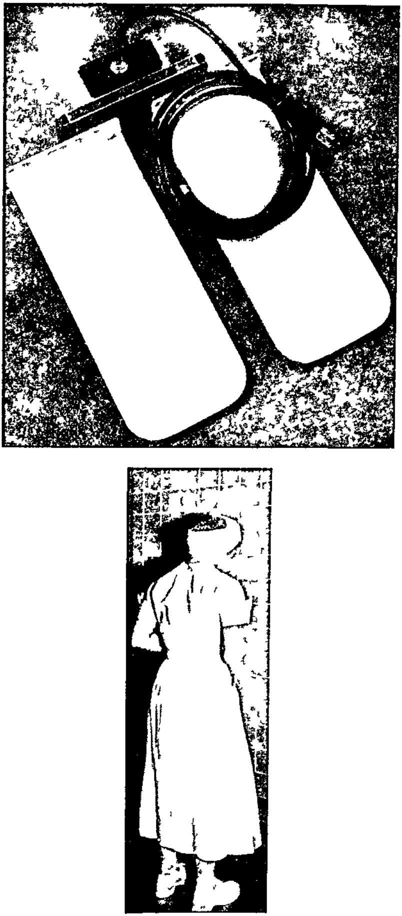

Fig 88 Ohmeter for determining conductivity of shoes of operating room personnel The instrument operates on ordinary 110 volt alternating current When the resistance of the shoes exceeds one megohm the light does not show and the shoes are not considered safe (Courtesy W E Anderson Co, Kansas City, Mo)

cools the wet one Differences in temperature are interpolated on the scale and relative humidity is read off in percent

Procedure or Use

1 Fill container with water at room temperature
2 Allow wick to soak well and wet bulb to cool (5 min)

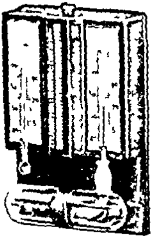

FIG 89 The wet-dry bulb thermometer used for determining humidity in operating room

3 Read both temperatures and subtract wet from dry
4 Turn scale on top of instrument until figure representing difference between two readings comes into view
5 Read down marginal scale to the figure corresponding to temperature of *dry* bulb Figure opposite is relative humidity in percent

WET TOWEL INTERCOUPLING

Principle The patient, anesthetist, operating table and anesthetic apparatus are interconnected with wet towels

Uses In situations in which high resistance flooring is present in an operating location and a Horton intercoupler is not available

Materials Three moistened towels with excess water squeezed out of them

Procedure

1 Drape one end of towel over the bare shoulder of the patient and tuck the other end between the pad and the table
2 Drape one end of second towel over base of operating table over caster or expanding metal part and other end on floor
3 Drape third towel over base of anesthetic machine and other end on floor towards table
4 Anesthetist places one foot in each towel

Comment

Both towels on floor may touch each other and anesthetist may then make contact with one foot

2 Allow one clip to rest on the floor or fasten to the lead to the ground
3 Encircle one band to patient's wrist (use wrist of arm used for blood pressure cuff)
4 Encircle one band around left wrist (anesthetist's)
5 Suspend the cylindrical portion on anesthesia machine by the hook provided for the purpose

Care of Intercoupler	*Reasons*
1 Arrange wires in such a manner that they do not become tangled or caught in castors of machines, table, or in feet of operating room personnel	If the leads are torn from the resistance, the unit is rendered useless
2 Disconnect all leads immediately after the operation is completed and wind wires into a compact bundle	The unit is often damaged when the machine is pulled away from the table, or the wires become hopelessly tangled

Comment	*Reasons*
1 *Remember* that the unit is theoretically sound but does not supersede conductive flooring in efficiency	The instrument should be employed routinely in suites with no conductive floors
2 *Always* wear the band on the left (anesthetist's) wrist	The right hand should thus remain free for charting and other duties
3 *Remember* that if a member of the coupled field comes into contact with power lines, shocks are minimized	A resistance of one megohm is sufficiently small to prevent discharges of large amounts of current
4 *Remember* that although the lead for the ground need not be connected, it is preferable to do so	Bodies outside the protected field which come into contact with the field usually have the same potential as the ground
5 *Remember* that the resistance between any two terminals is unaffected by any connection to the other terminals	A resistance of one megohm exists between any two terminals
6 *Remember* that a spark may occur between objects in the interconnected field and objects outside the field	A resistance of one megohm allows the potential to be equalized in one thousandth of one second, this allows sufficient time for a spark to form under these circumstances

Testing Humidity in Operating Room

Principle The wet and dry bulb thermometer combination is used (Fig 89) The wet bulb is surrounded by a wick immersed in water Evaporation

2 Remove the headband from beneath the occiput	It may be soiled in the event emesis occurs
3 Remove secretions by suction using a metal curved pharyngeal suction tip	Secretions may cause laryngeal spasm, tracheal or bronchial obstruction, or initiate retching and vomiting during the recovery period
4 Remove the artificial airway as soon as the patient reacts from anesthesia and the pharyngeal or laryngeal reflex returns	Its presence may initiate retching and vomiting by pharyngeal stimulation
5 Remove secretions, mucus, and wipe secretions from the face and mouth	Irritation to the skin occurs if they are not removed
6 Disconnect the intercoupler and fold neatly	The leads may be broken off when the machine is rolled away from operating table
7 Remove the cuff of the sphygonomanometer and the stethoscope and fold neatly	The apparatus is usually removed in the operating room
8 Unfasten and remove restraints from legs and wrists	An unconscious patient is easily injured if attempts are made to lift him while he is in restraints
9 Transfer patient to the stretcher and place him in the position desired by the surgeon	The airway is the anesthetist's responsibility at all times, and he must observe it continuously during the recovery period
10 Place a towel, airway, and tongue depresser alongside the patient's head	Be prepared to combat obstruction and emesis en route to patient's room
11 Stand at the "head end" of the stretcher and proceed to the patient's room Support the chin to maintain a free airway (Fig 75, page 220)	The anesthetist's responsibility ends only when the patient is no longer in danger of asphyxia, or circulatory or respiratory failure

Routine in Halls and Elevator	*Reasons*
1 Cover patient with a blanket (woolen blanket not to be put on in operating room)	Movements of the blanket may create electrostatic charge which is dangerous if inflammable gases have been employed
2 Carefully observe respiration and the airway Reinsert pharyngeal airway if necessary	Patients frequently lapse into deep sleep following emergence from anesthesia and develop respiratory obstruction

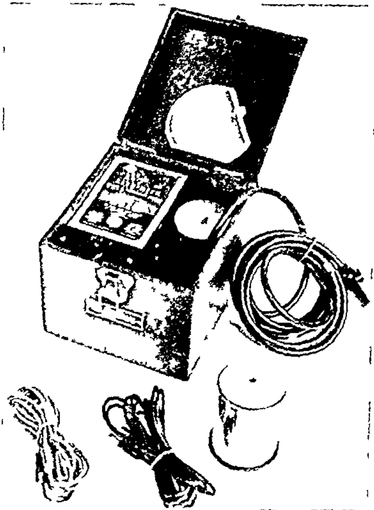

FIG 90 The megger used to determine resistances of equipment in operating rooms and conductivity of floors The circular weights are placed three feet apart on the conductive floor Floors having resistance of more than half a megohm or less than 25 000 ohms are not acceptable (Courtesy W E Anderson Co Kansas City Mo)

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Greene, B A The Hazard of Fire and Explosion Anesthesiology, *2* 144, March, 1941

Horton, J W The Present Status of the Problem of Preventing Anesthetic Explosions Anesthesiology, *2* 121, 1941

CARE OF PATIENT AT TERMINATION OF ANESTHESIA

The period following the discontinuance of anesthesia and before the complete recovery occurs is often the most critical and the one in which accidents are frequent

The following precautions should be followed to prevent and minimize accidents

Routine While Patient Is in Operating Room	*Reasons*
1 Remove the mask from the face and turn patient's head to one side	This allows secretions to readily pass from the mouth in event of retching or emesis

pinch and pass it into the tracheal tube	
6 Replace mask on the inhaler, have it in readiness for administration of oxygen or resuscitation in event of complications	Spasm of the larynx or obstruction of airway may follow withdrawal of catheter and the inhaler will be required immediately
7 Withdraw the catheter from the trachea when the laryngeal reflex returns or the patient coughs	The possibility of respiratory obstruction from relaxation of tissues is lessened if muscles of pharynx and tongue regain tone
8 Apply suction to the pharynx again after removal of the tracheal catheter	If secretions in the catheter are not completely removed, they pass into pharynx as catheter is withdrawn

Care of Patient in "Shock" at End of Operation	*Reasons*
1 Adjust shoulder braces and place the patient in the Trendelenburg position if surgeon desires it	This improves circulatory status of medullary centers
2 Adjust inhaler, administer pure oxygen by semi closed system at 6 liters per minute	Inhalation of oxygen may be beneficial in peripheral circulatory failure
3 Turn on filter to remove carbon dioxide	Carbon dioxide is undesirable because it produces hyperpnea and may contribute further to circulatory changes
4 Remove anesthetic drug by allowing exhalation valve to remain open	Rebreathing of exhaled gases may keep patient anesthetized even though the concentration is low
5 Do not remove restraints from knees	Patient may become restless or delirious
6 Do not remove sphygmomanometer until patient is ready to be returned to his bed	Blood pressure readings should be taken frequently
7 Maintain fluids, a free airway, and provide warmth	The patient should not be returned to his room until the circulation assumes a satisfactory status

Comment and General Precautions	*Reasons*
1 At the termination of operations about the neck or face, do not remove patient to his bed until he *recovers completely from anesthesia*	Edema, tight bandages, secretions, etc, may cause obstruction or laryngeal spasm if patient is not observed closely

Routine on Ward or in Patient's Room	*Reasons*
1 Request attendants to close doors and windows	Drafts and chilling may predispose to respiratory complications
2 Place patient in bed in position desired by surgeon	The position should be one that insures free airway at all times
3 Note character and rate of the pulse and record the blood pressure on the chart	Circulatory depression frequently occurs after termination of anesthesia and changes in position
4 Place patient in the custody of a nurse or other responsible attendant as soon as he recovers and his reflexes return	All unconscious subjects should be observed continuously to avoid respiratory obstruction, aspiration, and other anesthetic accidents common in the recovery period

Routine Following Cyclopropane, Nitrous Oxide, Ethylene, or Vinethene Anesthesia	*Reasons*
1 Continue anesthesia up to moment of application of dressing	Elimination of these agents is rapid and undesired premature recovery from anesthesia and restlessness of patient occurs
2 Remove mask and empty inhaler Proceed as listed under general directions and perform duties which apply to this type of anesthesia	Accumulation of inflammable mixtures in the inhaler is undesirable

Routine Following Intratracheal Anesthesia	*Reasons*
1 Remove packs or deflate cuff, and loosen any adhesive which anchors the catheter to the skin	The catheter should be free so that it may be removed instantly when desired
2 Apply suction to the pharynx using a curved metal tip If necessary, expose hypopharynx with laryngoscope to completely remove secretions	Remove secretions completely to prevent laryngeal spasm
3 Remove the "bite block" and replace it with an oropharyngeal airway	This prevents obstruction which may follow removal of catheter It also acts to prevent patient's biting on catheter
4 Disconnect intratracheal catheter from inhaler and allow patient to recover by breathing air	Aspiration of pharynx is more easily accomplished if the patient remains anesthetized
5 Attach a lubricated 14 or 16 French, or other catheter of appropriate size, to the suction,	Remove secretions from the trachea and tracheal catheter as completely as possible

PART IV

BASAL NARCOSIS AND ANALGESIA BY INTRAVASCULAR INJECTION

Principle An aqueous solution of a central nervous system depressant is injected directly into the vascular system The method is suitable for water soluble drugs It is used most extensively for non-volatile drugs The drug is administered by the intermittent, fractional or by the continuous infusion (drip) technique

Available Drugs

Ether Ether is shaken with physiological saline, the excess removed, and the aqueous solution injected This is rarely employed because ether is only moderately soluble in water and the volume of solution necessary to maintain surgical anesthesia therefore would be too great

Paraldehyde This drug is useful for hypnosis but not satisfactory for surgical anesthesia The dose and duration of anesthesia are variable and not easily estimated

Alcohol Ethyl alcohol is mixed with distilled water and 5% dextrose and infused for analgesia

Tribromethanol The action and duration of this agent are variable and it is rarely used

Narcotics These are suitable for analgesia, basal hypnosis, or as a supplemental agent for inhalation or other types of anesthesia Morphine, dihydromorphinone (dilaudid), meperidine (demerol), methadon, nisentil are the most commonly employed drugs

Barbiturates Short acting barbiturates are used for sedation and as anticonvulsants Sodium amytal, pentobarbital, and secobarbital are the most useful of this group

Ultra short-acting barbiturates are used for anesthesia Thiopentobarbital (pentothal) surital, kemithal and evipal are the most commonly employed and popular in this group They also are prepared in aqueous solutions of their sodium salt Barbiturates are not analgesic to any extent and can only be used for basal narcosis

Steroid compounds Viadril is currently used for basal narcosis

Local anesthetics These are diluted and administered for premedication, analgesia and for vasodilatation

Methods of Administration

1 *Intravenous* This is the most accessible and commonly employed route The following sites listed in the order of frequency of use are utilized for the injection

2 Never allow a patient having an artificial airway in situ to remain unattended	Stimulation of the pharynx by the airway may induce spasm, retching, or vomiting which may be unnoticed and cause asphyxia
3 Do not remove the patient from the operating room if he commences to vomit or retch	Suction the pharynx and allow the patient to remain in operating room until the episode is over
4 Do not disassemble inhaler until patient is out of operating room	Complications frequently occur at termination of anesthesia which require immediate use of an inhaler
5 Remain with the patient from the moment anesthesia is induced until he is safely in bed and can be left in custody of a responsible person	Obstruction, vomiting, or spasm, are so frequent and develop so quickly that even a moment's relaxation of vigilance may be fatal
6 Allow the head to hang over the end of the stretcher if the patient vomits en route to bed Use suction freely on arrival in patient's room	This prevents aspiration of foreign material or fluid into respiratory tract by allowing it to gravitate into the nasopharynx where it is less harmful
7 Never allow a patient's arms or legs, hands, or feet to dangle over side of operating table or stretcher	Injury to limbs, paralysis of radial nerve or brachial plexus from pressure or traction may occur during transit
8 Close main valves on cylinders on machine before leaving operating room	Attendants may jar cylinders loose while cleaning room and cause contained gases to escape

Procedure

1. Locate the manubrium of the sternum
2. Prepare the skin thoroughly with the desired antiseptic
3. Raise an intradermal wheal several centimeters caudad to the center of the manubrium
4. Infiltrate deeper structures over and including the periosteum
5. Insert the sternal needle in a cephalad direction inclining the needle at an angle approximately 20° to 30° to the skin and pierce the bone

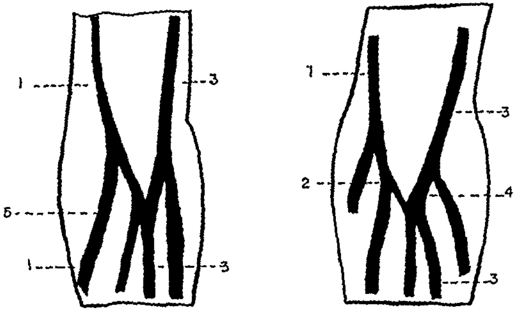

Fig 91 Two common arrangements of the veins of the left cubital fossa In the obese the veins are deeply subcutaneous and not visible or palpable 1 Basilic 2 Median basilic 3 Cephalic 4 Median cephalic 5 Median cubital

6. Attach syringe and aspirate when needle pierces bone and is felt to pass into marrow (Blood is drawn into the syringe if the needle is in marrow cavity)
7. Clear needle by injecting several cc 's of physiological saline solution
8. Inject desired fluid in the same manner and with the same precautions used for an intravenous injection

Precautions

1. Do not proceed with the injection unless marrow contents are aspirated
2. Do not employ the technique in the face of local infections of the thorax, sternum, or septicemia
3. Be positive that the needle has not pierced the lower plate of the sternum and has passed into the mediastinum

REFERENCE

Papper I M The Bone Marrow Route for Injecting Fluids and Drugs Into the General Circulation Anesthesiology 3 307 1942

a Median basilic vein and other veins in antecubital fossa
b Veins of the plexus on dorsum of the hand
c Internal saphenous at inner aspect of the ankle, or the lateral marginal vein at the ankle
d Veins of plexus on dorsum of the foot
e Internal and external jugular veins

2 *Intramedullary* Fluids may be injected into the marrow cavities of the large bones Absorption is as rapid and effective as if given by vein The sternum is preferred as the site of injection in adults Long bones are used in children

3 *Intra arterial* This route is dangerous Arterial spasm may occur which may be followed by gangrene of an extremity particularly when a terminal artery is used

TECHNIQUE OF VENIPUNCTURE

1 Expose the arm well above the cubital fossa Prepare the skin with ether or 70% alcohol
2 Raise an intradermal wheal using a 26 or 27 gauge needle over the selected vein, using a 0 5% or 1% procaine solution as the anesthetic agent
3 Shift wheal to side of vein by retracting the skin laterally
4 Apply the tourniquet close to site of venipuncture to fix the vein (a blood pressure cuff may be used)
5 Insert an 18 or 19 gauge needle through the wheal at the side of the vein into the tissue surrounding the vein
6 Relax the tension on the skin and allow the needle and wheal to shift back over vein
7 Puncture the vein and hold needle so that bevel is parallel to wall of vein
8 Release tourniquet

Comment

1 The extremity may be wrapped with hot packs to cause veins to be come prominent if they are difficult to visualize
2 Local anesthesia is optional and may be omitted

REFERENCE

Lundy John and Adams Charles Intravenous Anesthesia Anesthesiology 1 145 1940

TECHNIQUE FOR STERNAL PUNCTURE

Materials

1 Hypodermic needle and syringe
2 *Special sternal needle (1 5 mm × 30 mm with a stylet)*
3 Procaine (0 5% or 1% solution)

4 19 or 20 gauge needle
5 Syringe holder (Fig 92)
6 Arm board
7 Tourniquet
8 Kreiselman resuscitator or other suitable device for artificial respiration
9 Artificial airway of proper size
10 Suitable skin sterilizer and sponges
11 Infusion of saline or 5% dextrose in distilled water and administration set
12 Three way stopcock
13 Towel or strap for fastening arm to the board

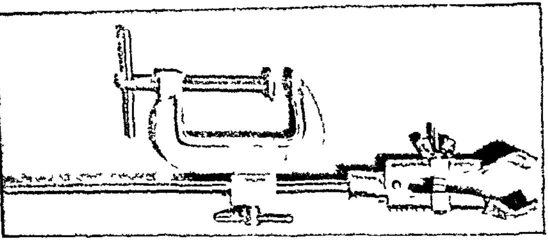

Fig 92 Simple syringe holder for intravenous administration of hypnotic and anesthetic drugs

Note The drug is usually packed in ampules containing either one gram or half gram Larger packages are available for bulk preparation of drug

Procedure

1 Arrange the cuff of the sphygmomanometer to the arm with the less suitable veins
2 Strap the arm with the most suitable veins to the board which has been placed in a convenient position Fasten the palm of the hand upward to the board If veins of arm are inaccessible, use those of foot
3 Explain to the patient details of the procedure to obtain his confidence
4 Prepare the skin, select the vein, apply tourniquet, and perform venipuncture as described in foregoing section Commence infusion or introduce needle attached to syringe in vein (Fig 93)
5 Fasten syringe holder to arm board and connect adapter to three way stopcock and to infusion if infusion is used
6 Inject 5–10 drops of drug to test for intolerance Wait several minutes
7 Inject the drug slowly, but do not exceed 2 cc in the first fifteen sec-

INTRAVENOUS SODIUM PENTOTHAL (THIOPENTAL)

Description Basal narcosis (profound hypnosis with amnesia) obtained by the administration of the ultra short acting barbiturate pentothal (sodium thiopentobarbital) Rapid loss of consciousness occurs Consciousness returns within a few minutes after termination of the injection but may be followed by a variable period of somnolence Reflexes are not completely abolished Not satisfactory as a surgical anesthetic when used alone Always used in conjunction with a drug which possesses analgesic properties

Uses

1 For brief minor procedures which require no marked degree of pain relief (without supporting drug)
2 For procedures in which general anesthesia is required in which the cautery or electrosurgical unit is employed (with nitrous oxide)
3 For narcointerrogation and narcoanalysis
4 For basal narcosis to facilitate induction and maintenance of inhalation anesthesia (In conjunction with nitrous oxide, ethylene, ether, cyclopropane and the muscle relaxants)
5 As a hypnotic and sedative with local or spinal anesthesia
6 For the relief of convulsive states produced by stimulating drugs (local anesthetics) or following increased irritability of the central nervous system (tetanus, rabies etc)

Dosage Average dose is 1 gm (15 gr) in 40 cc of distilled water or physiological saline solution ($2\frac{1}{2}\%$) Dosage varies with the patient

Preparation The patient is prepared in the same manner and same principles and precautions are observed as for other types of general anesthesia

Premedication	*Reason*
1 Atropine, hyoscyamine or scopolamine gr 1/150 to 1/100, one hour prior to anesthesia	This is necessary because it antagonizes vagal effects and minimizes secretions
2 Morphine, gr 1/6 to 1/4, one hour prior to anesthesia	This may be omitted because it tends to enhance the respiratory depression characteristic of pentothal It is analgesic and reduces the amount of pentothal used

Materials

1 Ampules of drug
2 Sterile distilled water or physiological saline
3 Syringe 20, 30 or 50 cc size equipped with a Luer lock for the needle or an adapter to fit a three way stopcock

9 Administer fractions of 1/2 to 1 cc of solution from time to time as the responses of the patient demands This can be judged only from the reactions of patient to the stimuli of surgery and the response to the drug Pause at least thirty seconds between fractions

10 Proceed with nitrous oxide, ethylene or cyclopropane

Signs of Anesthesia

No reliable signs of pentothal anesthesia exist The stages and planes applicable to inhalation anesthesia cannot be used as guides to anesthesia with the barbiturates Slow administration of barbiturates results in various zones of "reactivity" which have been likened to planes of anesthesia However, rapid and repeated administration results in a telescoping of these "stages" The anesthetist must attempt to maintain the patient between the zones of decreased reflexed activity and respiratory and circulatory failure

Complications	*Reasons*
1 Respiratory failure	This is usually due to an overdosage or to the use of large quantities of drugs over long periods of time
2 Hypotension	This is due to depression of the vasomotor and hypothalamic centers from the initial or too large a dose
3 Laryngeal spasm	This is caused by spasmogenic qualities of thiobarbiturates Mucus, blood, and other secretions or any instrumentation of the pharynx and larynx in respiratory tract may initiate the spasm
4 Coughing and sneezing	The laryngeal and pharyngeal reflexes are not abolished by the drug Stimulation of the cornea (eye surgery) may cause sneezing
5 Slough at site of injection	This is due to extravascular injection of the solution Solutions of the sodium salts of barbiturates are alkaline (pH 9 to 10) and cause damage to tissues in event of seepage
6 Phlebothrombosis	The alkalinity of the solution causes damage to the vessel wall
7 Arteriospasm	This is caused by accidental intra arterial injection Gangrene of the extremity may follow the spasm

onds Stop and wait (patient will be narcotized in 30–40 seconds) Repeat, if anesthesia does not ensue, repeat using same amount of solution at same rate

8 Support the chin to insure a patent airway as soon as consciousness is lost

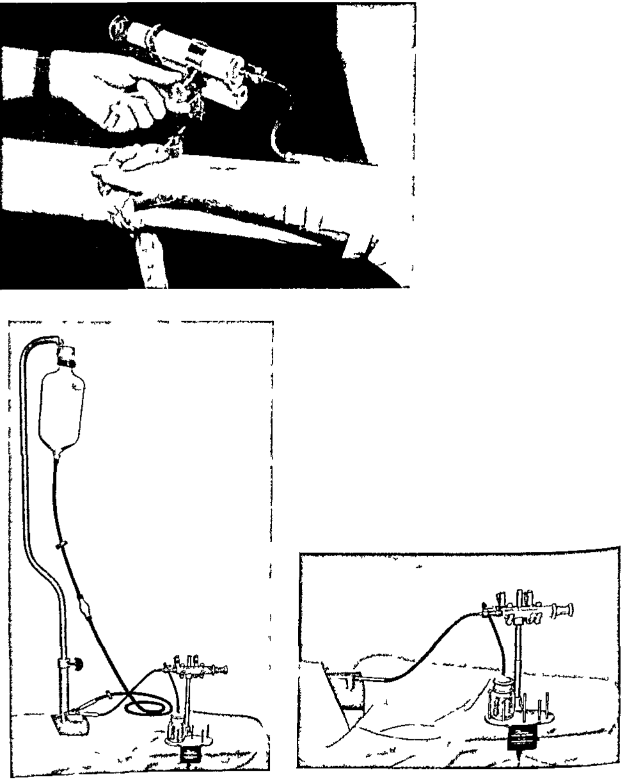

Fig 93 Administration of pentothal using various types of syringe holders

3 Hypotension due to contracted blood volume and other causes	The vasomotor center is depressed by the drug and the hypotension may be enhanced. Drug is slowly detoxified in shock states
4 Chronic diseases of the respiratory tract complicated by a decrease in vital capacity	The drug depresses respiration. Hypoventilation may follow
5 Acute or chronic obstruction of the respiratory tract (edema of the glottis, Ludwig's angina, etc.)	Obstruction from spasm may further affect the respiratory difficulty. Asphyxia may result when voluntary efforts to maintain airway patent are removed
6 Anemia regardless of the cause	May be hazardous if respiratory depression occurs because oxygen carrying power of the blood is reduced
7 Patients, who have sepsis, or who are cachetic or comatose	The drug may be detoxified so slowly in these subjects that a marked respiratory or circulatory depression or prolonged somnolence occurs
8 As a sole agent for operations in the pharynx, larynx, or bronchi, particularly if secretions are abundant	Laryngeal spasm may develop because pharyngeal and laryngeal reflexes are not abolished
9 Acidosis from any cause	Respiratory depression may enhance acidosis by causing a retention of carbon dioxide in the tissues
10 Diseases of the liver and kidney	Acidosis may complicate these diseases. Detoxifying powers of the tissues may be poor and prolonged narcosis may follow
11 As a sole agent for operations of undetermined length	Large amounts of the drug may be necessary to complete the operation. This causes a marked depression of respiration and circulation from cumulative effects
12 As a sole agent for "major" operations and those requiring muscle relaxation	Pentothal does not produce satisfactory muscle relaxation if used alone

Precautions	*Reasons*
1 The limit should be approximately one gram of the drug for an adult	The drug is promptly removed and stored in the adipose tissues. Prolonged narcosis results because it accumulates and is slowly

8 Prolonged somnolence	Ultra short acting barbiturates are only partially detoxified immediately Degradation products accumulate in the tissues and cause hypnosis if large amounts are given
9 Twitchings of muscles	Cause not determined May be due to hypothermia, CO_2 excess, or cold environment or degradation products from detoxification of drug

Advantages

1 Induction of basal narcosis is simple, rapid, and accompanied by amnesia which is pleasant to the patient
2 Basal narcosis may be induced in the patient's room as indicated
3 A minimum of apparatus is required
4 Post-anesthetic emesis is reduced (if the patient has been fasting)
5 It does not stimulate the production of secretions in the respiratory tract
6 It causes no irritation to the mucous membranes of the respiratory tract
7 Recovery is prompt in vigorous subjects if minimal doses are employed

Disadvantages

1 The basal narcosis is noncontrollable Once the drug is in a vein, and overdosage has occurred, it cannot be retrieved, and one must wait until it is detoxified
2 All reflexes are not abolished, particularly those of the larynx and pharynx, and laryngeal spasm may develop
3 It cannot be used as the sole agent because it is not analgesic and causes anesthesia by inducing a severe depression
4 The necessary effective dose is difficult to estimate because of differences in susceptibility of individuals to barbiturates
5 A severe respiratory depression may ensue The sensitivity of the respiratory center to carbon dioxide decreases progressively
6 It is spasmogenic giving rise to severe laryngeal and bronchial spasm
7 The muscular relaxation is not satisfactory, unless general anesthetics or muscle relaxants are also used

Contra-Indications

1 Aged subjects with manifestations of degenerative changes	Detoxification may be delayed
2 Diseases of the heart	Objectionable primarily from deleterious effects it may have on respiration Small doses permissible

3 Hypotension due to contracted blood volume and other causes	The vasomotor center is depressed by the drug and the hypotension may be enhanced Drug is slowly detoxified in shock states
4 Chronic diseases of the respiratory tract complicated by a decrease in vital capacity	The drug depresses respiration Hypoventilation may follow
5 Acute or chronic obstruction of the respiratory tract (edema of the glottis, Ludwig's angina, etc)	Obstruction from spasm may further affect the respiratory difficulty Asphyxia may result when voluntary efforts to maintain airway patent are removed
6 Anemia, regardless of the cause	May be hazardous if respiratory depression occurs because oxygen carrying power of the blood is reduced
7 Patients, who have sepsis, or who are cachetic or comatose	The drug may be detoxified so slowly in these subjects that a marked respiratory or circulatory depression or prolonged somnolence occurs
8 As a sole agent for operations in the pharynx, larynx, or bronchi, particularly if secretions are abundant	Laryngeal spasm may develop because pharyngeal and laryngeal reflexes are not abolished
9 Acidosis from any cause	Respiratory depression may enhance acidosis by causing a retention of carbon dioxide in the tissues
10 Diseases of the liver and kidney	Acidosis may complicate these diseases Detoxifying powers of the tissues may be poor and prolonged narcosis may follow
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12 As a sole agent for "major" operations and those requiring muscle relaxation	Pentothal does not produce satisfactory muscle relaxation if used alone

Precautions	*Reasons*
1 The limit should be approximately one gram of the drug for an adult	The drug is promptly removed and stored in the adipose tissues Prolonged narcosis results because it accumulates and is detoxified slowly

8 Prolonged somnolence	Ultra-short acting barbiturates are only partially detoxified immediately Degradation products accumulate in the tissues and cause hypnosis if large amounts are given
9 Twitchings of muscles	Cause not determined May be due to hypothermia, CO_2 excess, or cold environment or degradation products from detoxification of drug

Advantages

1 Induction of basal narcosis is simple, rapid, and accompanied by amnesia which is pleasant to the patient
2 Basal narcosis may be induced in the patient's room as indicated
3 A minimum of apparatus is required
4 Post anesthetic emesis is reduced (if the patient has been fasting)
5 It does not stimulate the production of secretions in the respiratory tract
6 It causes no irritation to the mucous membranes of the respiratory tract
7 Recovery is prompt in vigorous subjects if minimal doses are employed

Disadvantages

1 The basal narcosis is noncontrollable Once the drug is in a vein, and overdosage has occurred, it cannot be retrieved, and one must wait until it is detoxified
2 All reflexes are not abolished, particularly those of the larynx and pharynx, and laryngeal spasm may develop
3 It cannot be used as the sole agent because it is not analgesic and causes anesthesia by inducing a severe depression
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5 A severe respiratory depression may ensue The sensitivity of the respiratory center to carbon dioxide decreases progressively
6 It is spasmogenic giving rise to severe laryngeal and bronchial spasm
7 The muscular relaxation is not satisfactory, unless general anesthetics or muscle relaxants are also used

Contra Indications

1 Aged subjects with manifestations of degenerative changes	Detoxification may be delayed
2 Diseases of the heart	Objectionable primarily from deleterious effects it may have on respiration Small doses permissible

complains of pain while injecting the drug during the induction	into the area This causes vaso dilatation and averts sloughing
14 Do not apply the tourniquet too tightly	The compression may cause arterial pulsation to disappear and intraarterial injection may accidently result if artery is mistaken for vein
15 Do not induce anesthesia by this technique unless artificial air ways and an inhaler for artificial respiration are available for instant use	The uncontrollable nature of this type of anesthesia renders it extremely hazardous unless precautions for treating overdosage are available
16 Do not use intravenous anesthesia for operations in which the anesthetist must be removed from absolute control of the airway	The airway should be under the control of the anesthetist at all times Use an endotracheal tube and topical anesthesia under such circumstances
17 Do not administer pentothal to patients who have recently partaken of food or fluid	Emesis frequently follows during recovery period The gastric contents may cause a severe spasm of the larynx
18 Do not use thiobarbiturates or short-acting barbiturates when suppurative diseases of the lungs are present	Secretions may initiate laryngeal and bronchial spasm
19 Use an infusion of saline or 5% dextrose in distilled water in *conjunction with barbiturate narcosis of undetermined length*	Technical difficulties due to maintaining vein patent are averted
20 Do not use solutions which have been standing for several days	Barbiturates are not stable Potency may have been lost

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INTRAVENOUS SODIUM SURITAL (THIOSECOBARBITAL)

Description Sodium surital is an ultra short acting thiobarbiturate whose pharmacological actions are essentially similar to pentothal The technique for administration and precautions are identical to those outlined for sodium pentothal

2 Do not use artificial airways if basal narcosis is uncomplicated by obstruction	Reflexes in the pharynx and trachea are not abolished and retching or spasm of larynx may result
3 Do not inject the drug before the tourniquet is released	Overdosage may occur if the drug is injected with tourniquet tightened and subsequently released
4 Be positive that the drug is completely dissolved and that the solution is clear before performing venipuncture	Undissolved particles act as foreign bodies in the solution and may cause "reactions"
5 Administer pure oxygen and assist respiration if cyanosis appears or if respiratory movements are shallow	Anoxemia due to the respiratory depression is thus avoided
6 Inject the solution slowly Do not inject more than 6 cc of a 2 1/2% solution at one time at the onset	Overdosage can be avoided by fractionation and grading the dose
7 Draw back as little blood as possible into the syringe (when an infusion is not used)	The blood proteins precipitate in the solution and the cells are hemolized Large volumes of blood tend to dilute the total volume of solution making it difficult to judge dosage accurately
8 From time to time ascertain whether or not the needle is in the vein and still patent by pulling on the plunger slightly if an infusion is not used	This should be done to avoid sloughs by extravascular injection and to prevent clotting in the needle during the maintenance of anesthesia
9 Clear blood from the needle by injecting a small amount of solution through it from time to time	Clotting of the blood in needle invariably occurs unless this is done
10 Do not add analeptic drugs to the solution of the barbiturate	Have such drugs in readiness in event of emergency Analeptic drugs antagonize the barbiturate action and defeat the purpose of the drug
11 Administer fractional maintenance doses only when the patient responds to stimuli	Pain is indicated by increased amplitude of respiration, phonation or reflex action
12 Do not employ for surgical anesthesia for office practice or for ambulatory patients	Ataxia may appear and persist for several hours in recovery period Resuscitative equipment and aid of assistants is usually not available in the office
13 Withdraw the needle and reinsert it into another vein if patient	This usually indicates extravascular injection Inject 1% procaine

	complains of pain while injecting the drug during the induction	into the area This causes vaso dilatation and averts sloughing
14	Do not apply the tourniquet too tightly	The compression may cause arterial pulsation to disappear and intraarterial injection may accidently result if artery is mistaken for vein
15	Do not induce anesthesia by this technique unless artificial air ways and an inhaler for artificial respiration are available for instant use	The uncontrollable nature of this type of anesthesia renders it extremely hazardous unless precautions for treating overdosage are available
16	Do not use intravenous anesthesia for operations in which the anesthetist must be removed from absolute control of the airway	The airway should be under the control of the anesthetist at all times Use an endotracheal tube and topical anesthesia under such circumstances
17	Do not administer pentothal to patients who have recently partaken of food or fluid	Emesis frequently follows during recovery period The gastric contents may cause a severe spasm of the larynx
18	Do not use thiobarbiturates or short acting barbiturates when suppurative diseases of the lungs are present	Secretions may initiate laryngeal and bronchial spasm
19	Use an infusion of saline or 5% dextrose in distilled water in conjunction with barbiturate narcosis of undetermined length	Technical difficulties due to maintaining vein patent are averted
20	Do not use solutions which have been standing for several days	Barbiturates are not stable Potency may have been lost

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INTRAVENOUS SODIUM SURITAL (THIOSECOBARBITAL)

Description Sodium surital is an ultra short acting thiobarbiturate whose pharmacological actions are essentially similar to pentothal The technique for administration and precautions are identical to those outlined for sodium pentothal

Variations in Technique

1 Dose—one gram for an adult of average size and weight 150–175 lbs
2 Strength—usually a $2\frac{1}{2}\%$ solution is necessary for successful anesthesia
3 Rate of injection—1 to 3 cc slowly 1/2 to 1 cc in 10 seconds for the induction The remainder at intervals determined by the reflex activity of the patient
4 The drug is not used alone but is combined with nitrous oxide, ethylene, cyclopropane The muscle relaxants may be added if relaxation is required

INTRAVENOUS SODIUM EVIPAL (HEXOBARBITAL)

Description Sodium evipal is an ultra-short acting barbiturate of the N-methyl type whose pharmacological actions, from a clinical standpoint, are essentially similar to pentothal

The technique of injection and precautions are identical to those for sodium pentothal except in the following details

Variations in Technique

Dose One gram for an adult of average size and weight (150–175 lbs)

Strength Usually a 5% to 10% solution is necessary for adequate basal narcosis

Rate of Injection One to three cc slowly (1/2–1 cc in 10 seconds) for the induction, the remainder at intervals determined by the reflex activity of the patient

SEDATION AND HYPNOSIS—WITH ULTRA SHORT ACTING BARBITURATES (DRIP TECHNIQUE)

Principle A dilute solution of pentothal, surital, or evipal is allowed to infuse intravenously at a rate to maintain hypnosis and sedation

Uses

1 For sedation and as adjunct to intravenous anesthesia
2 For narcointerrogation (crime investigation) and narcoanalysis (psychiatry)
3 For management of convulsive states

Materials Same as described for pentothal In addition 1000 cc 5% dextrose in distilled water

Preparation of Patient Administer anticholinergic drug—atropine or scopolamine

Procedure

1 Dissolve 2 gm pentothal, surital or evipal in 1000 cc solution
2 Perform venipuncture and perform sensitivity test by allowing few drops of solution to drip and then clamping tube and waiting several minutes
3 Commence drip rapidly until patient is unconscious and slow down to maintain narcosis at desired levels

NARCOINTERROGATION USING PENTOTHAL (TRUTH SERUM)

Purpose Narcointerrogation is performed on subject for the purpose of securing information for legal and other purposes The subject is not a patient in the acceptable sense of the word but should be treated and managed as though he is

Procedure

1 Secure proper signed permission with witnesses
2 Perform test in an operating room where all appliances of an emergency and resuscitative nature are available
3 Have patient fasting
4 Premedicate with atropine or scopolamine
5 Narcotize as described above, using drip technique and pentothal, surital or evipal Allow patient to lose consciousness Allow to return to semi narcotized state at level where conversation is coherent but he obviously is sleepy

Comment	*Reason*
1 Allow patient to pass into narcotized state and return to semi narcotized state before beginning interrogation	Amnesia is not fully developed unless this is done
2 Restrain patient's legs, arms may be left free	Patient may roll off bed or table in narcotized state or upon emergence
3 Allow only authorized persons to be present and interrogate subject	Medicolegal complications may arise if this is not done
4 Do not administer drug too rapidly	Patient passes into deep sleep and does not respond to questioning
5 Do not exceed 1–1 1/2 grams of pentothal	If given intermittently the dilute solution permits 2–3 hours interrogation
6 Have facilities for urination available	Polyuria follows use of infusion of glucose and distilled water

7 Provide a place for recovery of patient after procedure	Are usually ataxic and drowsy for several hours later
8 Fasten arm on a board	Patient moves about and dislodges needle if this is not done
9 Be prepared to cope with nausea, spasm, apnea and hypotension	These complications are as apt to occur in this as any other procedure
10 Administer benzedrine or caffeine (1/2 gram I M) when procedure is over	These act as cortical stimulants and help wake patient up

BASAL NARCOSIS USING SHORT-ACTING BARBITURATES

Description A deep hypnosis induced by the intravenous or intramuscular injection of secobarbital (seconal), pentobarbital (nembutal) amobarbital (amytal)

Uses

1 To "steal" patients who are uncooperative, apprehensive, excitable
2 For basal narcosis preliminary to general anesthesia
3 For sedation during regional anesthesia (spinal, etc)
4 As anti convulsants
5 As premedication when intravenous ultra short-acting barbiturates cannot be used

Preparations Seconal dissolved in polyethylene glycol Pentobarbital in propylene glycol—10% Amobarbital in water

Procedure Seconal, pentobarbital or amobarbital

1 Slowly administer *the selected solution undiluted intravenously in divided doses of 50 mgm each at 3–5 min intervals preferably into the* infusion tubing until 100–150 mgm of any of the three drugs has been given stopping if less is required

Comment	*Reason*
1 Do not administer more than 150 mgm at any one time	Respiratory depression and overdosage may result
2 Do not give continuously in fractions (like pentothal)	Overdosage results Drug is not stored in lipoids like pentothal, but passes directly into brain
3 Allow time for effect to be established (Fig 94)	Latent period varies from 3–5 minutes for seconal and longer for other drugs
4 Do not expect profound hypnosis similar to pentothal	These drugs are not as potent as the thiobarbiturates
5 Do not use for surgical anesthesia (as when spinal "wears off")	Barbiturates are non analgesic and do not abolish pain

6 Supplement with morphine or pentothal if maximum has been given and hypnosis is wearing off	These drugs fortify the barbiturate which is in tissues and enhances effect
7 Do not use same dose routinely for everyone	Remember doses of barbiturates are variable from person to person Always administer in fractions for this reason

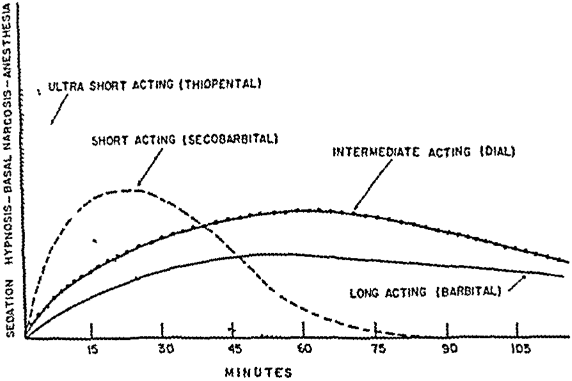

Fig 94 Differences in intensity, onset and duration of action and lag or latent period between various types of barbiturates administered intravenously in basal narcotic doses

INTRAVENOUS PARALDEHYDE

Description Basal narcosis of several minutes' duration followed by a variable period of hypnosis induced by injecting intravenous paraldehyde

Uses

1 To rapidly sedate disoriented, unruly subjects (patients with delerium tremens etc)
2 To control convulsions

Dosage Four to five cc for an adult of average size and weight (150–175 lbs)

Technique Inject the pure drug slowly (1 cc per 30–40 seconds) into suitable vein Precautions and technique are essentially the same as mentioned above for sodium pentothal

Contra Indications

1 Debilitated, cachetic, or anemic patients

7 Provide a place for recovery of patient after procedure	Are usually ataxic and drowsy for several hours later
8 Fasten arm on a board	Patient moves about and dislodges needle if this is not done
9 Be prepared to cope with nausea, spasm, apnea and hypotension	These complications are as apt to occur in this as any other procedure
10 Administer benzedrine or caffeine (1/2 gram I M) when procedure is over	These act as cortical stimulants and help wake patient up

BASAL NARCOSIS USING SHORT-ACTING BARBITURATES

Description A deep hypnosis induced by the intravenous or intramuscular injection of secobarbital (seconal), pentobarbital (nembutal) amobarbital (amytal)

Uses

1 To "steal" patients who are uncooperative, apprehensive, excitable
2 For basal narcosis preliminary to general anesthesia
3 For sedation during regional anesthesia (spinal, etc)
4 As anti convulsants
5 As premedication when intravenous ultra short acting barbiturates cannot be used

Preparations Seconal dissolved in polyethylene glycol Pentobarbital in propylene glycol—10% Amobarbital in water

Procedure Seconal, pentobarbital or amobarbital

1 Slowly administer the selected solution undiluted intravenously in divided doses of 50 mgm each at 3–5 min intervals preferably into the infusion tubing until 100–150 mgm of any of the three drugs has been given stopping if less is required

Comment	*Reason*
1 Do not administer more than 150 mgm at any one time	Respiratory depression and over dosage may result
2 Do not give continuously in fractions (like pentothal)	Overdosage results Drug is not stored in lipoids like pentothal, but passes directly into brain
3 Allow time for effect to be established (Fig 94)	Latent period varies from 3–5 minutes for seconal and longer for other drugs
4 Do not expect profound hypnosis similar to pentothal	These drugs are not as potent as the thiobarbiturates
5 Do not use for surgical anesthesia (as when spinal "wears off")	Barbiturates are non analgesic and do not abolish pain

Materials

1 Intravenous set with 18–20 gauge needle
2 1000 cc 5% alcohol in 5% dextrose in distilled water

Procedure

1 Perform venipuncture
2 Commence flow of alcohol solution, giving initial dose of 50 to 200 cc within 10 to 15 minutes
3 Adjust the drip to 40 to 80 drops per minute, to suit needs of patient

Comment

1 Reduce flow if restlessness and signs of inebriation appear
2 Administer one liter in 3 to 6 hours
3 Limit total to not more than 3 liters in 24 hours

Advantages

1 Does not depress respiration
2 Does not depress the heart
3 Acts as a vasodilator

Disadvantages

1 Analgesic qualities of alcohol questionable
2 Patient must be watched closely
3 Sclerosis of the veins may occur
4 Cold solutions may initiate pain and discomfort along the course of the veins
5 Rapid administration may cause inebriation in some patients
6 Not all patients respond favorably—excitement and little or no analgesia results

INTRAVENOUS HYDROXYDIONE (VIADRIL)

Principle Analgesia and basal narcosis induced by injection of the sodium salt of the non endocrine sterol, Viadril

Uses

1 For basal narcosis in conjunction with nitrous oxide, ethylene, cyclopropane, ether and other anesthetics
2 To supplement spinal anesthesia which is "wearing off"
3 For minor procedures in which analgesia is desired

Preparation Same as that for basal narcosis with other intravenous agents

Premedication A narcotic (morphine or meperidine) and anticholinergic drug in usual dosages

2 The presence of acute or chronic diseases of the respiratory tract
3 Acidosis from any cause
4 Diseases of the liver and kidneys

INTRAVENOUS ETHER

Description The administration of ethyl ether in saline by the intravenous route

Uses

1 For vasodilatation
2 For bronchial dilatation (in spasmogenic states)
3 As a fortifying agent for analgesia with basal narcosis

Procedure

1 Add ether from freshly opened can to normal saline—about 6 cc per 100 cc solution
2 Shake and siphon off excess floating on surface
3 Commence drip of solution as rapidly as patient tolerates 80–120 drops per minute

Objections

1 Excitement and disorientation common
2 Large volume of solution required to obtain anesthesia
3 Coughing, salivation common unless anti cholinergic drug is used
4 Hemolysis and hematuria common
5 Phlebitis may occur

Comment

1 The ether is excreted by the lungs
2 Analgesia and hypnosis cannot be obtained by use of ether alone—use basal narcosis

INTRAVENOUS ETHYL ALCOHOL

Description The intravenous administration of dilute solutions of ethyl alcohol preoperatively or postoperatively

Uses

1 For analgesia, preoperatively or postoperatively
2 As a source of energy for parenteral feeding
3 As a vasodilating agent (for the relief of spinal headache, angina pectoris, etc)
4 As an aid in detoxifying methyl alcohol in poisoning

3 Muscle relaxation may be augmented by use of succinyl choline
4 "Tightening" may be overcome by additional narcotic intravenously (meperidine 15 mgm) instead of the sterol

NARCOTICS BY THE INTRAVENOUS ROUTE

Definition Analgesia and sedation induced by injection of narcotics intravenously Opium alkaloids and their derivatives or synthetic analgesics may be used

Uses

1 For rapid premedication for emergency surgery
2 As a supplemental agent to regional anesthesia
3 To quickly obtain analgesia for severe pain, from colic, spasm, etc
4 For sedation and analgesia for endoscopy and other minor procedures

Dose The amount required varies with the individual, his age, general state, metabolic rate, and other factors When morphine is used the average dose is 1/6 to 1/4 gr The range may be 1/8 to 1/2 gr Use 1/2 to 2/3 of that which would be used if the subcutaneous route were employed For other drugs see Table IV

Technique (Direct injection)

1 Dissolve or dilute the desired dose in normal physiological saline so that each cubic centimeter contains 1/8 gr of morphine sulphate or equivalent of other narcotic
2 Draw the solution into a hypodermic syringe attached to a 1½ or 2" 26-gauge needle and inject it at approximately 1 cc per minute

Comment	*Reason*
1 Do not inject the drug rapidly	Dizziness, tinnitus, or nausea, hypotension and even apnea may result Cease injection momentarily and proceed at a slower rate if these symptoms appear
2 Allow a period of ten minutes to elapse prior to induction of anesthesia if the drug is administered for pre anesthetic medication	The peak effect is established within 10–15 minutes
3 Mix narcotic with anticholinergic drug if used for premedication One part scopolamine hydrobromide to 25 of morphine sulphate or equivalent dose of other narcotic may be combined to enhance effects of the sedative	The drugs are compatible

Materials

1 Same arrangement and materials used for pentothal using infusion of 5% glucose in distilled water or saline, 1 gm ampule of drug

Procedure

1 Dissolve the sterol in distilled water to make a 1½ or 2% solution
2 Introduce in fractions of 1/8–1/4 gm over 5–10 minute period until 1 0–1 5 grams have been administered and patient is asleep
3 Commence nitrous oxide or other selected anesthetic

Characteristics of Drug

1 Not satisfactory as a sole agent
2 Onset of action gradual requiring 10–15 minutes for establishment of basal narcosis
3 Appears to potentiate other analgesics and anesthetics—not satisfactory if used alone except for superficial procedures
4 Rapid awakening after discontinuance of nitrous oxide or other rapidly eliminated anesthetic
5 Easily soluble in water to form an alkaline solution (pH 7–8)
6 Single dose sufficient for many hours Fractionation not required once initial dose is administered
7 Respiratory depression uncommon
8 Laryngeal spasm does not occur Airway tolerated after establishment of narcosis
9 Nausea and vomiting uncommon in postoperative period
10 Allows basal narcosis for long operations
11 Does not disturb cardiac rhythm
12 Patient may be intubated

Disadvantages

1 Phlebitis and thrombosis occur particularly when administered directly into vein without infusion
2 Tachypnea frequent Rates as high as 60 noted
3 Nausea may occur if rapidly injected
4 Transient hypotension occurs upon injection
5 Muscle relaxation not always adequate if used alone
6 Appears to be more effective in older than younger subjects
7 Long latent or lag period before effects are established
8 Increases in the pulse rate common

Comment

1 The average dose appears to be 1 to 1½ gm
2 The hypotension responds to vasopressors

2 Do not exceed flow of 4 cc per minute (1 gm in 1 hr)
3 Decrease rate of infusion if dizziness, tremors, excitement or other symptoms of central nervous system stimulation appear
4 Watch blood pressure and pulse Procaine is a circulatory depressant

Comment

1 The procedure is of doubtful value

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MUSCLE RELAXANTS AS ADJUNCTS TO ANESTHESIA

Purpose To cause muscle relaxation by inhibiting transmission of nerve impulses at the myoneural substance of skeletal muscle by the use of blocking agents The muscle relaxants are non anesthetic and must therefore be used in combination with anesthetic or analgesic agents They act by
1 Preventing the nicotinic action of acetyl choline
2 Causing persistent depolarization of the membrane at the myoneural junction

Uses

1 To obtain relaxation in resistant subjects during cyclopropane or ether anesthesia
2 To obtain relaxation when light anesthesia is required and deep anesthesia is contraindicated
3 To obtain relaxation with agents not ordinarily capable of yielding it such as nitrous oxide, ethylene, or pentothal
4 To obtain relaxation for laryngoscopy and intubations Used in conjunction with inhalation and local anesthesia for this purpose
5 As a supplement to spinal or other regional block which is "wearing off" in conjunction with inhalation anesthesia
6 To control convulsions or muscle spasms during anesthesia
7 To cause apnea for thoracic surgery or other techniques in which apnea is indicated

Available Drugs Curare and a variety of synthetic muscle relaxants are available as adjuncts to anesthesia Curare is available as an aqueous solution of the mixture of the purified alkaloids The standard preparation contains 20 units of curare per cc The purified alkaloid, tubocurarine, which is the active principle, is preferred *The newer drugs are listed in* Table VIII

4 For direct injection use a longer needle than ordinary hypodermic needle	The hypodermic needle does not easily enter a vein if less than 1" long
5 Inject drug into infusion tubing if a vein has been cannulated	The saline or other solution acts as the diluent
6 Do not use in the presence of hepatic or renal disease	These subjects are sensitive to narcotics

INTRAVENOUS PROCAINE

Description The infusion of dilute procaine hydrochloride solution so that the blood concentration is maintained below the subtoxic level Beneficial effects are supposed to be due to vasodilatation and analgesia

Uses

1 For analgesia for minor brief procedures such as removal of dressings, debridements, or first stage of labor
2 For relief of intractable itching (jaundice)
3 For relief of allergic states—serum sickness, chronic asthma, urticaria, etc
4 For relief of vasospastic states
5 To reduce myocardial irritability in thoracic surgery

Materials

1 Sterile procaine crystals (1 gm)
2 Sterile 5% dextrose in distilled water
3 Dispensing set for infusion
4 Blood pressure apparatus

Procedure

1 Dissolve the procaine in 1000 cc of dextrose in distilled water
2 Arrange infusion so that bottle is approximately 3½ to 4 ft above arm level
3 Perform venipuncture in the usual manner for infusion and allow solution to drip at the rate of 2 cc per minute for several minutes
4 Increase rate to 3 or 4 cc per minute depending upon the therapeutic response of the patient (tinnitus, diplopia, tremors)

Contra-Indications

1 Circulatory depression, shock, hypotension etc
2 Liver or renal disease
3 Hyperirritable states of nervous system

Precautions

1 Perform skin and intranasal tests with the solution before starting infusion if possibility of intolerance to drug exists (Part VI)

Dosage Average size adults tolerate 80–100 units or approximately 0 5 unit per lb of body weight Dose varies with the individual and with the anesthetic agent employed and degree of relaxation required

Procedure Using Curare

1 Anesthetize the patient with the desired anesthetic agent in the usual manner with the usual premedication
2 Introduce the estimated quantity of drug into a vein or infusion tube when the skin incision is made Administer the drug in divided doses of 20 units each allowing 3 minutes between injections
3 Intubate patient

Duration Relaxation of muscles is established within 3 or 4 minutes Under anesthesia action remains apparent for 30–45 minutes

Precautions

1 Edrophonium (Tensilon), 5–10 mgm intravenously should be available to overcome overdosage	This drug antagonizes the curare action by retarding destruction of acetyl choline at the nerve endings and by displacing the curare
2 Intubate the patient and be prepared to do controlled or assisted respiration	Complete paralysis of muscles of respiration may follow administration Hypoventilation common
3 Take body weight into consideration in estimating dose	Large doses may cause death by circulatory failure even though adequate pulmonary ventilation is maintained
4 Administer drug in divided doses	Overdosage is averted thereby
5 Decrease dose to one third of average dose when used with ether	Ether possesses a curare like action Overdosage may result
6 Use one third to one half the initial dose when repeating the drug	A cumulative action occurs when the drug is repeated
7 Do not mix drug with pentothal solutions when using the combination	A precipitate forms due to incompatability
8 Do not use drug intramuscularly for anesthesia	Absorption rate is too slow, onset of action is 15 minutes by this route
9 Do not use without an anesthetic or analgesic drug	Curare does not possess any pain relieving properties
10 Do not use in the presence of renal insufficiency	A depressant effect follows due to slow excretion
11 Watch circulatory system closely	A hypotension may follow extreme relaxation

TABLE VIII

Muscle Relaxants

Drug	*Curare*	*Tubocurarine*	*Dimethyl Tubocurarine*	*Benzoquinonium*	*Gallamine*	*Decamethonium*	*Succinyl Choline*
Proprietary name	Intocostrin		Metubine Mecostrin	Mytolon	Flaxedil	Syncurine C10	Anectine Sucostrin
Onset I.V. min	1½–2	1½–2	1½–2	2½–3	1½–2	2–3½	½–1
Peak effect—min	5	5	5	6–10	2½–6	5	1–2
Duration—min	25	25	20	15	15	5–12	3
Dose per 70 kgs—154 lbs	60–100 units 3–5 cc.	9–15 mgm	3–16 mgm	9–15 mgm	60–80 mgm	3–4 mgm	20–40 mgm.
Repeat Dose	½ initial	½ initial	½ initial	½	½ initial	Tachyphylaxis. Do not use	Use infusion Approx 4 mgm. per min.
Dose with Ether	⅓ as much	⅓ as much	⅓ as much	⅓ as much	⅓ as much	No reduction	No reduction
Dose with Cyclopropane	No reduction	No reduction	No reduction	No reduction	No reduction	No reduction	No reduction
Dose with Pentothal Surital or Evipal	No reduction	No reduction	No reduction	No reduction	No reduction	No reduction	No reduction
Antagonist	Edrophonium (Tensilon) 5–10 mgm Neostigmine	Edrophonium (Tensilon) 5–10 mgm Neostigmine	Edrophonium (Tensilon) 5–10 mgm Neostigmine	Edrophonium (Tensilon) 5–10 mgm Neostigmine	Edrophonium (Tensilon) 5–10 mgm Neostigmine	None available	None Blood transfusion

Baird's solution 1 cc (100 units) curare added to 19 cc 2.5% pentothal contains 5 units per cc

6 Remember muscle relaxants are not analgesic	Administer analgesic and hypnotic drugs concomitantly

Advantages

1 It is short acting The action can be reversed at will
2 By products of detoxification are normally found in body (choline and succinic acid)
3 Hydrolized by pseudo cholinesterase which is found in serum
4 May be "titrated" to obtain relaxation as desired
5 Autonomic effects negligible
6 Does not possess histamine like action and cause bronchial spasm
7 Does not ordinarily depress nervous system

Disadvantages

1 In some individuals an apnea may result (central depression)
2 No antidote available which is wholly satisfactory
3 It must be infused for sustained effect

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INTRAMUSCULAR SECONAL (SECOBARBITAL)

Uses For premedication in infants and children

Dose 3/4–1 mgm per pound of body weight—1 hour prior to anesthesia in conjunction with anticholinergic drugs

COMBINATIONS OF MUSCLE RELAXANTS AND THIOBARBITURATES PENTOTHAL—CURARE—(DRUGS SEPARATE)

Principle Hypnosis is obtained by the use of the barbiturate and a muscle relaxant Nitrous oxide is added for analgesia

Materials

1 Infusion set
2 Syringe holder
3 Three way stopcock
4 Syringes for pentothal (30–50 cc)
5 Syringe for relaxant (10 cc)
6 Airway, resuscitator, Tensilon and other items as above

12 Do not administer to point of apnea	Large doses may depress centrally
13 Watch patient closely in postoperative period	Recurarization may occur due to redistribution of drug
14 Do not use in dehydrated patients	These appear to be more sensitive to effects of the drug
15 Do not use when acidosis or hypopotassemia is present	These patients manifest an unusual sensitivity to the drug
16 Do not use when a bronchial spasm exists or is easily induced (asthma)	Curare and tubocurarine induce a histamine like action

SUCCINYL CHOLINE (DRIP METHOD)

Principle Succinyl choline (Anectine, Sucostrin) is rapidly hydrolized by cholinesterase Its action is brief—several minutes at the most For sustained effect it must be administered by a continuous drip intravenously

Uses

1 To obtain relaxation with general anesthetic agents
2 To obtain relaxation for electro shock therapy

Procedure

1 Add sufficient stock solution of succinyl choline chloride or iodide to normal saline or 5% dextrose in distilled water so that solution has 1 mgm of drug per cc
2 Induce anesthesia with desired agent
3 Permit succinyl choline to pass rapidly into blood stream until 20 mgm have been given, then pinch tubing
4 Allow 1–2 minutes to elapse and note effect of this initial dose Add additional 10 mgm fractions until desired relaxation is obtained
5 Resume administration at rate required to maintain desired degree of relaxation

Comment	*Reason*
1 The iodide contains less of the active principle than the chloride	Iodine has a higher molecular weight than chlorine
2 Exercise care in administration to cachetic, chronically ill individuals	The serum cholinesterase may be low in these individuals
3 Always assure an adequate airway by using an endotracheal tube	Apnea results May be sustained in exceptional cases
4 Use fresh whole blood to overcome prolonged apnea	Whole blood adds cholinesterase to patients blood
5 Label bottle conspicuously	Avoid error Infusion may be left on after operation

PENTOTHAL SUCCINYL CHOLINE NITROUS OXIDE

Procedure

1 Induce and maintain anesthesia as above carrying patient to apnea and continue to drip succinyl choline maintaining apnea
2 Control respiration manually or by machine (Part VII)

Comment

1 Procedure hazardous because overconcentration of succinyl choline may result
2 Procedure not controllable—patient may "wake up" from pentothal and remember events or painful stimulation during operation

DEMEROL (MEPERIDINE)—PENTOTHAL SUCCINYL CHOLINE DRIP

Principle Demerol in dilute solution is administered alternately with pentothal in dilute solution

Procedure

1 Prepare solution of demerol 0 5 mgm per cc in 5% dextrose in distilled water or in saline
2 Prepare pentothal 1 gm in 1000 cc 5% dextrose in distilled water
3 Prepare succinyl choline 1 mgm per cc in saline
4 Cannulate vein using 3 way stopcock
5 Administer scopolamine gr 1/100 I V prior to anesthesia
6 Connect solutions to stopcock
7 Administer 75–100 mgm demerol slowly over 5–10 minutes (at rate of 30–40 drops per minute
8 Administer pentothal to point of loss of consciousness Administer succinyl choline as needed
9 Allow demerol to drip as needed Determine requirements according to respiratory rate of patient and by reflex activity
10 Add pentothal as required to maintain narcosis Supplement with nitrous oxide (see table for flow and percentage composition)

REFERENCE

Ausherman H, Nowill W K and Stephen C R Controlled Analgesia with Continuous Drip Meperidine Exhibit A M A, June, 1955

Procedure

1 Commence infusion with saline or 5% dextrose in distilled water
2 Connect 3 way stopcock and pentothal syringe with infusion
3 Pinch off infusion tubing and narcotize patient with pentothal (use technique described previously)
4 Add muscle relaxant into infusion tubing in divided doses
5 Intubate and control or assist respiration
6 Start nitrous oxide (see table for percentage composition of gas and flow
7 Add pentothal or curare as each is needed

PENTOTHAL CURARE MIXTURE (BAIRD'S SOLUTION)

Procedure

1 Mix 1 cc "strong" curare (100 units) with 19 cc 2 5% pentothal One cc =5 units curare
2 Administer solution slowly until patient is narcotized and relaxed
3 Intubate and maintain anesthesia by adding fractions are required

Comment

1 Do not use the more dilute solution of curare—precipitation results
2 Substitute tubocurarine (3 mgm per 20 units) for curare if desired

VARIATIONS FOR ABOVE

Surital, or evipal may be substituted for the barbiturate, and syncurine, flaxedil or mytolon or methyl tubocurarine may be used for the relaxant (see table for dosage)

PENTOTHAL-SUCCINYL CHOLINE

Procedure

1 Commence infusion with 3 way stopcock, etc as described above
2 Connect 3 way stopcock to syringe containing 2½% pentothal
3 Mix solution of saline containing 1 mgm succinyl choline per cc and connect to stopcock
4 Narcotize patient with pentothal
5 Clear pentothal from tubing and needle with infusion fluid to prevent precipitation
6 Commence succinyl choline allowing 20 mgm to flow in rapidly
7 Intubate patient (use topical anesthesia)
8 Alternate pentothal and succinyl choline allowing the succinyl choline to drip at rate necessary to maintain relaxation
9 Assist or control breathing

hensive patients (hyperthyroidism, psychoses, neuroses, etc)	a patient in his bed as a premedicating agent
2 To control hyperirritable states of the central nervous system, such as convulsions, tetanus, and similar excitabilities	The drug is a depressant of the central nervous system, particularly the cerebral cortex
3 To relieve "status asthmaticus"	Tribromethanol causes relaxation of the bronchi
4 For intracranial surgery	Tribromethanol causes a lowering of intracranial pressure

Cubic centimeters of avertin fluid per kilo and per pound of body weight Use 33 cc. for each cc. of drug to make a 3% solution

Mgm Per Kilo	Cc. Per Kilo	Cc Per Lb
60	0 060	0 0270
65	0 065	0 0295
70	0 070	0 0315
75	0 075	0 0339
80	0 080	0 0360
85	0 085	0 0380
90	0 090	0 0405
95	0 095	0 0427
100	0 100	0 0450
105	0 105	0 0472
110	0 110	0 0493
115	0 115	0 0517
120	0 120	0 0540

Dosage

Adult—60–80 mgm per kilogram of body weight in a 3% aqueous solution at 37°–40°C (100–104°F) by rectum

Children—80–100 mgm per kilogram of body weight in same concentration

1 The maximum amount under ordinary circumstances should not exceed 8 cc for females and 10 cc for males

2 Increase the dose if the metabolic rate is above normal to 80–100 milligrams per kilogram

Premedication and Preparation	*Comment*
1 *Morphine*—1/6 to 1/4 gr one hour before the administration of avertin	This drug is omitted by some anesthetists because avertin depresses the respiratory center and the depression from the combination of the two drugs may be severe
2 *Atropine or scopolamine*—1/150 to 1/100 gr one hour before the	These drugs are used to decrease secretions which may be produced

PART V

RECTAL ANESTHESIA

Definition Anesthesia, analgesia, or amnesia, produced by the rectal instillation of anesthetic or hypnotic drugs

Available Drugs

1 *Tribromethanol* This drug dissolved in amylene hydrate is known as *avertin* An aqueous solution of avertin is the most commonly employed and most useful agent
2 *Trichlorethanol* This drug is similar to tribromethanol and is used for the same purposes, in the same manner
3 *Paraldehyde* This drug is frequently employed in oil or in an aqueous solution to produce sedation or basal narcosis
4 *Ether* A mixture of ether in oil is used for analgesia
5 *Barbiturates* The most useful of this group of drugs are the short acting-derivatives They produce an intense, deep hypnosis

Comment

1 Drugs instilled into the rectum in the form of an enema pass into the colon The ileocecal valve is not patent Little absorption occurs from the small intestine, unless the valve is patent
2 Drugs absorbed from the intestines are carried by the portal system to the liver where they may be modified or stored
3 The capacity of the rectum varies from one individual to the next but averages between 150 and 200 cc
4 Rectally administered drugs do not produce complete anesthesia but rather a partial anesthesia or "basal narcosis" Reflexes arising from pain stimuli are rarely abolished by certain non-volatile drugs used for basal narcosis so that supplemental anesthesia is required

BASAL NARCOSIS WITH AVERTIN

Definition A deep hypnosis produced by the rectal instillation of an aqueous solution of tribromethanol dissolved in amylene hydrate (avertin fluid)

Description of the drug Tribromethanol is a solid crystalline substance which is very soluble in amylene hydrate Avertin is a clear colorless liquid with a camphor like odor, consisting of one gram of tribromethanol dissolved in one half gram of amylene hydrate, which equals one cubic centimeter Therefore, each cubic centimeter of fluid contains 1000 milligrams of tribromethanol

Uses	*Reasons*
1 For "psychic sedation" in appre	The drug may be administered to

12 A tongue depressor
13 A sphygmomanometer (the aneroid type is preferred)
14 An ampule of metrazol (1 cc of 10% solution)
15 A sterile hypodermic syringe and needle for the analeptic
16 Lubricant for the catheter
17 A pinch clamp or artery forceps for the catheter
18 A tray on which utensils for mixing and instilling the drug should be kept

Calculations of the Required Volume of Drug

The weight of patient in pounds multiplied by the factor 00045, the result multiplied by the dose (milligrams per kilogram), equals number of cubic centimeters of avertin fluid required

The number of cubic centimeters of avertin fluid multiplied by 33 equals the number of cubic centimeters of water necessary to prepare a 3% solution

Example

Patient's weight is 154 pounds
Dosage requested by physician is 80 mgm of tribromethanol per kilogram of body weight
154 pounds × 00045 equals 0693
0693 × 80 equals 5 54 cc avertin fluid
5 5 × 33 0 equals 181 cc water necessary for a 3% solution

Procedure Begin preparation of the solution at least 45 minutes before the time of operation The solution may be prepared in the anesthesia room

1 Measure the calculated amount of distilled water in the graduate and place it in the thin walled flask
2 Warm the water to 103 or 104° F, or 39 to 40° C, by holding the flask in a stream of hot tap water Use the thermometer
3 Aspirate the calculated volume of avertin into the 10 cc calibrated syringe and add it to the warmed water in the flask
4 Add several drops of Congo red solution to the entire solution—the color should remain red A blue color indicates that the solution contains an acid and, therefore, decomposition has occurred
5 Shake mixture until all the avertin is dissolved and no globules are visible at the bottom of the flask
6 Warm the interior of thermos bottle with hot water and transfer the solution to it
7 Proceed to the patient's room with the stretcher, an attendant, the prepared solution, and the necessary implements to complete the instillation
8 Screen the bed, apply the sphygmomanometer, and record the blood pressure, pulse, and respiration

administration of avertin	by supplemental inhalation anesthetic drugs
3 Prescribe a cleansing enema four to five hours or more before time of the operation	Absorption of the drug will not be satisfactory unless the colon and rectum are evacuated
4 Weigh patient well in advance of the operation	The weight of the patient is necessary to calculate the amount of the drug required

Materials (Fig 95)

1 A 25 or 100 cc container of avertin
2 A thermometer to measure the temperature of the solution

Fig 95 Assembly for rectal administration of avertin

3 A rectal catheter, size 16 to 20 French
4 A glass funnel with stem which fits into the mouth of the rectal catheter
5 A thin walled glass flask (preferably a pyrex, Erlenmeyer flask, of 500 cc capacity)
6 A thermos bottle—500 cc capacity
7 A 10 cc graduated syringe
8 A 500 cc graduate
9 A vial of Congo red indicator (1/1000 aqueous solution)
10 An eye dropper for the Congo red indicator
11 A pharyngeal airway

12 A tongue depressor
13 A sphygmomanometer (the aneroid type is preferred)
14 An ampule of metrazol (1 cc of 10% solution)
15 A sterile hypodermic syringe and needle for the analeptic
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7 Proceed to the patient's room with the stretcher, an attendant, the prepared solution, and the necessary implements to complete the instillation
8 Screen the bed, apply the sphygmomanometer, and record the blood pressure, pulse, and respiration

9 Arrange a draw sheet beneath the patient so he may be removed from the bed when narcotized
10 Request the patient to turn on his left side and insert the well lubricated catheter into the rectum for approximately six inches
11 Attach the funnel to the catheter and instill the entire amount of solution into the rectum as quickly as it will flow by the aid of gravity
12 Clamp the catheter Do not remove it from the rectum
13 Strap the buttocks together with two strips of adhesive which extend from the lateral aspects of the thighs This prevents expulsion of the catheter and solution
14 Replace patient in supine position and allow him to remain undisturbed until narcosis ensues
15 As soon as the patient is narcotized (about 15 minutes), lift him onto the stretcher and remove him from his room to the anesthesia room
16 Proceed with the supplemental anesthesia selected for the particular case The following techniques are usually employed
   a Nitrous oxide or ethylene with oxygen If relaxation is desired, ether may be added or a muscle relaxant may be used
   b Cyclopropane with a muscle relaxant
   c Ether, open drop
   d Nerve blocks, infiltration or topical anesthesia

Supplemental anesthesia is induced and maintained in the same manner as anesthesia without avertin Many of the signs of anesthesia are obscured by avertin and depth of anesthesia is judged with difficulty

Characteristics of Avertin Narcosis

Onset Consciousness is lost within 5 to 10 minutes Narcosis is well established in 30 minutes

Duration Narcosis may last anywhere from 1 1/2 to 2 1/2 hours The duration is variable and unpredictable

Depth The stages and planes used as guides during inhalation anesthesia are not applicable to avertin narcosis because
1 Superficial reflexes are not abolished Painful stimuli tend to rouse the patient The drug is not an analgesic
2 Pharnyngeal and laryngeal stimulation cause gagging
3 Oculomotor, pupillary, and lid reflexes are abolished as soon as narcosis is established and remain obtunded

Advantages of Avertin

1 Patient may be narcotized in his room and taken to the operating room in an unconscious state Apprehension is avoided
2 The onset of narcosis is rapid and recovery is gradual The pre anesthetic and post anesthetic periods are clouded by amnesia

3 Excitement during induction is uncommon
4 There is a decrease in metabolic rate and reduced reflex irritability

Disadvantages	*Reasons*
1 The depth of narcosis is uncontrollable	Once the drug is administered it cannot be retrieved even when the rectum is emptied One must rely upon the mechanism of detoxification for elimination from the tissues
2 The dose is difficult to estimate accurately	Susceptibility to the drug varies between different individuals
3 The superficial reflexes are not completely abolished The narcosis must be supplemented by inhalation or regional anesthesia in order to abolish all reflexes	Pathways from periphery to cortex are not completely blocked during narcosis as with some agents
4 The duration of the narcosis varies and is not predictable (usually 1½ to 2½ hours)	It is influenced by the rate of absorption, elimination, and metabolic state of the subject which are variable
5 Narcosis is frequently induced in locations and in situations where oxygen and appliances for resuscitation are not instantly available	The drug is usually administered in the patient's room
6 The circulatory, respiratory, and other physiological functions are disturbed	Profound pharmacological changes are common
7 Excitement during emergence is occasionally observed	Usually it is precipitated by stimulation, particularly by pain

Contra Indications	*Reasons*
1 Acute or chronic infections of the respiratory tract	Secretions may cause coughing or precipitate laryngeal spasm The reflexes in the respiratory tract are obtunded but not completely abolished
2 Diseases accompanied by a decrease in vital capacity	A marked depression of respiration occurs due to medullary depression It invariably occurs if large doses are employed
3 Diseases of the heart—hypertension, hypotension, anemias, and other circulatory disturbances	Hypotension, characterized by a fall in systolic pressure and a decrease in pulse pressure, is common Respiratory depression may affect the circulation secondarily

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10 Request the patient to turn on his left side and insert the well lubricated catheter into the rectum for approximately six inches
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2 The onset of narcosis is rapid and recovery is gradual The pre-anesthetic and post anesthetic periods are clouded by amnesia

7 *Overdosage*—This is caused by
   a Careless preparation of solutions
   b Incorrect weight used for calculations
   c Calculations incorrect
   d Error in estimation of dose required for the particular patient

Comment	*Reasons*
1 Remain with the patient from the moment of injection of drug until complete recovery has occurred	Relaxation of pharyngeal structures and falling backward of the tongue cause asphyxia from respiratory obstruction
2 Do not insert artificial airways into the pharynx unless absolutely necessary	The pharyngeal and laryngeal reflexes are not abolished during avertin narcosis Coughing or retching occurs unless supplemental anesthesia is employed
3 Administer the solution at least 30 minutes before the scheduled time of operation	Absorption of the drug and establishment of complete narcosis may require at least 30 minutes
4 Use only freshly prepared solutions	The drug is easily decomposed by light, heat, or air Solutions which are allowed to stand any length of time become impure
5 Avoid overheating the solution	Irritating byproducts (hydrobromic acid and aldehydes) may form
6 Maintain the solution at body temperature until it is injected	Patients expel cold solutions The solubility of the drug decreases as the temperature falls and the drug may precipitate from the solution
7 Shake the solution well and be positive that the drug is completely dissolved	Undissolved avertin sinks to the bottom of the flask when added to water and remains there after watery portion is drawn off Underdosage results
8 Always use distilled water to prepare avertin solution	Tap water may contain minerals and salts which hasten deterioration of the drug
9 Never use an old or deteriorated solution	Proctitis or colitis may result
10 Support the chin constantly to maintain an unobstructed airway	Obstruction to respiration may easily result from the relaxation of the tongue and muscles of the neck
11 Always apply restraints to the patient on the stretcher when en route to operating room Observe	The patient may not be completely narcotized and suffer injury should restlessness or excitement ensue

4 Nephritis and other diseases accompanied by renal insufficiency	The products of detoxification are eliminated by the kidneys
5 Diseases of the liver or other conditions accompanied by hepatic insufficiency	Liver function is decreased during avertin narcosis The drug is detoxified by the liver by conjugation with glycuronic acid
6 Diabetes or acidosis from any cause	The carbon dioxide combining power is decreased by avertin Carbon dioxide is retained due to the respiratory depression
7 Diseases of or operations upon the rectum or colon	The solution may irritate the mucosa of the rectum or may not be entirely absorbed and interfere with the operation

COMPLICATIONS

1 *Respiratory failure*—Caused by overdosage or asphyxia due to obstruction Treat by
  a Artificial respiration
  b Analeptic drug, such as metrazol, intravenously
  c Empty the rectum by loosening the clamp on the catheter
2 *Failure to obtain narcosis*
  a Dose was underestimated or incorrectly calculated
  b The drug was not thoroughly dissolved
  c The solution was expelled around the catheter or the catheter was not left *in situ*
  d The cleansing enema was omitted or not satisfactory, or the avertin was administered too soon after the enema
  e The avertin was not added to the water
  f The patient is "resistant" to the drug
3 *Circulatory failure*
  a The drug was given to a patient with a circulatory deficiency
  b Overdosage—circulation fails secondary to respiration
4 *Proctitis*—Follows the use of decomposed or overheated solutions of the drug
5 *Prolonged drowsiness*—Usually due to
  a Overdosage or incorrectly calculated dose
  b The presence of hepatic or renal insufficiency or other disturbances which prevent normal detoxification
  c Use of the drug in aged individuals
  d The use of repeated successive doses of the drug
  e Prolonged use of supplemental agents such as ether
  f Use of another nonvolatile drug in conjunction with avertin
6 *Skin rash*—This is uncommon but is possibly caused by elimination of compounds containing bromine which is derived from the avertin

7 *Overdosage*—This is caused by
a Careless preparation of solutions
b Incorrect weight used for calculations
c Calculations incorrect
d Error in estimation of dose required for the particular patient

Comment	*Reasons*
1 Remain with the patient from the moment of injection of drug until complete recovery has occurred	Relaxation of pharyngeal structures and falling backward of the tongue cause asphyxia from respiratory obstruction
2 Do not insert artificial airways into the pharynx unless absolutely necessary	The pharyngeal and laryngeal reflexes are not abolished during avertin narcosis Coughing or retching occurs unless supplemental anesthesia is employed
3 Administer the solution at least 30 minutes before the scheduled time of operation	Absorption of the drug and establishment of complete narcosis may require at least 30 minutes
4 Use only freshly prepared solutions	The drug is easily decomposed by light, heat, or air Solutions which are allowed to stand any length of time become impure
5 Avoid overheating the solution	Irritating byproducts (hydrobromic acid and aldehydes) may form
6 Maintain the solution at body temperature until it is injected	Patients expel cold solutions The solubility of the drug decreases as the temperature falls and the drug may precipitate from the solution
7 Shake the solution well and be positive that the drug is completely dissolved	Undissolved avertin sinks to the bottom of the flask when added to water and remains there after watery portion is drawn off Underdosage results
8 Always use distilled water to prepare avertin solution	Tap water may contain minerals and salts which hasten deterioration of the drug
9 Never use an old or deteriorated solution	Proctitis or colitis may result
10 Support the chin constantly to maintain an unobstructed airway	Obstruction to respiration may easily result from the relaxation of the tongue and muscles of the neck
11 Always apply restraints to the patient on the stretcher when en route to operating room Observe	The patient may not be completely narcotized and suffer injury should restlessness or excitement ensue

similar precautions when patient is on the table during the preoperative period in the operating room	
12 Record blood pressure, pulse, and respiratory rate every *five minutes* after the patient is narcotized	Circulatory and respiratory depression may develop rapidly in some circumstances
13 Reexamine the calculations if more than 8 cc of avertin fluid are required There is possibility of an error	Maximum dose should not exceed 10 cc unless patient is large
14 *Do not attempt to* use avertin alone for complete anesthesia Always use supplemental agents	*Pathways from periphery to the* cortex are not completely blocked *Other drugs are necessary to assist* in abolishing reflexes
15 Do not administer repeated successive doses of avertin except in instances of sustained stimulation (tetanus, convulsions, etc)	The drug may accumulate in tissues due to slow detoxification and cause prolonged, sustained depression
16 Store avertin in a cool place	Heat, light, and oxygen hasten the decomposition of the drug
17 Remember that amylene hydrate possesses mild narcotic properties	The drug is a tertiary amyl alcohol

"Stealing" a Patient with Avertin

Definition The administration of avertin to a patient without his being aware of the fact that he is to be narcotized and undergo surgery

Uses For performing operations upon extremely apprehensive patients The procedure is widely employed for preparation of patients with thyrotoxicosis

Procedure

1 Weigh patient several days before the operation and estimate the volume of avertin solution which will be required
2 Administer an enema consisting of a volume of physiological saline equivalent to the volume of avertin solution Add several drops of Congo red to the saline and instill by the same technique as described for avertin
3 Remove the catheter after several hours
4 Repeat the instillation of saline for two or three days before the operation at approximately the same time of day the operation is to be performed
5 *Substitute the solution of avertin for the saline on the scheduled day* of operation

Comment

1 Administer the saline solution in exactly the same manner as the avertin
2 Select one individual to administer all the enemas and caution him not to vary the technique at any time
3 Do not administer the premedication until patient is narcotized by the avertin
4 Do not apply the sphygmomanometer until the patient is narcotized
5 Instruct nurses and attendants not to discuss the procedure or mention details of surgery to the patient
6 Instruct nurses, operating room attendants, and others not to enter patient's room until narcosis is established
7 Do not transfer the patient to the stretcher until narcosis is established

REFERENCES

Adriani, John Pharmacology of Anesthetic Drugs 3rd Ed Page 57 Charles C Thomas Springfield Ill 1955
Council of Pharmacy and Chemistry Report, J A M A, *109* 953, 1937
Waters, R. M, and Muehlberger, C W Avertin, Arch Surg, *21* 887, 1930

BASAL NARCOSIS WITH TRICHLORETHANOL

Definition A deep hypnosis produced by the rectal administration of an aqueous solution of trichlorethanol

Uses Same as for avertin

Description Trichlorethanol is a clear, colorless liquid possessing an ethereal odor No amylene hydrate is required as a solvent because the drug is a liquid

Cost Relatively inexpensive The manufacture of the drug is not restricted by patent, as is avertin

Dose For adults, 100–125 mgm per kilogram The specific gravity of the drug is 1 550 Therefore, 1 cc equals 1,550 milligrams of drug

Calculations of Required Volume of Drug

The weight of the patient in pounds multiplied by 00045, multiplied by milligrams per kilogram, divided by 1 55 equals the number of cubic centimeters of trichlorethanol fluid required

The number of cubic centimeters of trichlorethanol multiplied by 33 equals the number of cubic centimeters of water required to make a 3% solution

Example Patient's weight is 154 pounds

Dosage requested by physician is 100 mgm per kilogram of body weight
154×0 00045 equals 0693

0693×100, divided by 1 55 equals 4 60 cc trichlorethanol fluid required
4 6×33 0 equals 151 8 cc water necessary to make approximately a 3% solution

Premedication Same as for avertin

Materials Same as for avertin

Procedure Prepare and administer the solution in the same manner as avertin

Advantages Its advantages over other drugs are the same as for avertin It is superior to avertin in the following ways

1 It is less expensive
2 It is somewhat more stable
3 It does not require amylene hydrate or other solvents as a vehicle

Disadvantages Its disadvantages over other drugs are the same as for avertin It is inferior to avertin in the following ways

1 It is less potent
2 Its response and duration of action are more variable
3 It causes a more pronounced respiratory depression
4 Its dose is judged with more difficulty and the results are more variable
5 The duration of hypnosis is shorter

Comment

1 The chemical configurations for tribromethanol and trichlorethanol are the same, save that the halogen atoms differ
2 The solution should be mixed, warmed, tested, and administered in the same manner as avertin

REFERENCES

Adriani John Pharmacology of Anesthetic Drugs 3rd Ed P 58 Charles C Thomas, Springfield, Ill 1955
Case E H Present Status of Trichlorethanol Anesthesiology *4* 523, September, 1943
Molitor H, and Robinson H Pharmacological Properties of Trichlorethanol Anesth and Analg *17* 258, September, 1938
Wood D A Avertin An Appreciation and Comparison Anesth and Analg, *17* 252, September 1938

PARALDEHYDE

Definition Analgesia and hypnosis produced by the rectal instillation of aqueous or oily solutions of paraldehyde

Uses

1 For sedation in apprehensive subjects The drug is employed, particularly for chronic alcoholic addicts and psychopathic subjects
2 For analgesia in obstetrics
3 For basal narcosis in inhalation anesthesia

Cost A relatively inexpensive drug

Description A colorless, mobile, slightly water soluble liquid, with a pungent, fruity, penetrating odor

Dose 1 0 to 1 5 cc per 10 pounds of body weight

Materials

1 Paraldehyde (U S P)

2 Benzyl alcohol (N N R)
3 A rectal instillation set similar to that employed for avertin

Premedication Morphine, gr 1/6 to 1/4, 3/4 to 1 hour previous to instillation Atropine or scopolamine, gr 1/150 to 1/100, 3/4 to 1 hour previous to instillation

Technique

1 Measure required volume of paraldehyde and add to it 1 5 cc of benzyl alcohol Use the lower limit dosage for obese, extremely old, or young subjects Mix well Follow the routine described under avertin for the instillation
2 Allow solution to flow by gravity into the rectum It should flow as rapidly as possible
3 Follow with 30 cc. of physiological saline to rinse out the catheter tube and dissipate the drug in rectum and colon
4 Clamp the catheter and follow directions described for avertin
5 Repeat dose when necessary

Advantages It is a non toxic drug in hypnotic doses

Disadvantages

1 It is partly eliminated through the lungs and causes irritation and salivation
2 It possesses a clinging odor which persists for several days in the vicinity of the patient
3 It is irritating to the mucous membranes of the rectum and colon
4 Its dose is estimated with difficulty because susceptibility varies between individuals
5 Its depth and duration of narcosis are non controllable

Contra Indications

1 Chronic infections of respiratory tract or any disease in which the vital capacity is decreased
2 Diabetes or acidosis from any cause
3 Diseases of the kidney or liver
4 Diseases of the colon or rectum

Comment

1 Observe the usual precautions for rectal anesthesia with avertin
2 Do not omit the benzyl alcohol It acts as a local anesthetic and prevents irritation to the rectal mucosa

REFERENCE

Kane H F and Roth G B Combined Oral and Rectal Administration of Paraldehyde for the Relief of Labor Pains Anesth and Analg , *19* 282 September, 1940

Materials Same as for avertin

Procedure Prepare and administer the solution in the same manner as avertin

Advantages Its advantages over other drugs are the same as for avertin It is superior to avertin in the following ways

1 It is less expensive.
2 It is somewhat more stable
3 It does not require amylene hydrate or other solvents as a vehicle

Disadvantages Its disadvantages over other drugs are the same as for avertin It is inferior to avertin in the following ways

1 It is less potent
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4 Its dose is judged with more difficulty and the results are more variable
5 The duration of hypnosis is shorter

Comment

1 The chemical configurations for tribromethanol and trichlorethanol are the same, save that the halogen atoms differ
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Uses

1 For sedation in apprehensive subjects The drug is employed, particularly for chronic alcoholic addicts and psychopathic subjects
2 For analgesia in obstetrics
3 For basal narcosis in inhalation anesthesia.

Cost A relatively inexpensive drug

Description A colorless, mobile, slightly water soluble liquid with a pungent, fruity, penetrating odor

Dose 1 0 to 1 5 cc. per 10 pounds of body weight

Materials

1 Paraldehyde (U S P)

4 Insert the catheter approximately six inches into the rectum
5 Allow the solution to flow into the rectum by gravity as rapidly as possible
6 Clamp but allow the catheter to remain in place Strap buttocks (as for avertin) to prevent expulsion of the solution
7 Return the patient to the supine position and observe the airway closely and insert the artificial airway if necessary
8 Attach the inhaler arranged for rebreathing, fill with oxygen, and allow the patient to rebreathe the exhaled ether

Signs of Anesthesia These are exactly the same as for ether anesthesia by inhalation

Advantages The analgesic effects of ether can be utilized to better advantage by this method than by inhalation

Disadvantages

1 The depth of anesthesia is non controllable Once the drug is administered, it is difficult to retrieve
2 The dosage cannot be estimated accurately Instillation may have to be repeated or supplemented Inhalation or other forms of anesthesia may be required
3 The duration of action is unpredictable It varies with size and metabolic state of the patient
4 It possesses the same pharmacological disadvantages as ether by inhalation
5 The greater part of it must be eliminated by the lungs
6 Excitement and salivation are common during induction or recovery

Contra Indications These are the same as for ether by inhalation

Complications

1 Overdosage—this is characterized by respiratory failure as with ether by inhalation
2 Proctitis—this is due to the irritating action of ether upon the mucosa
3 Respiratory obstruction—this is due to relaxation and obstruction of the airway, as in inhalation anesthesia
4 Excitement—this is caused by ineffective premedication, insufficient ether, or slow absorption
5 Salivation—this results because the belladonna alkaloid is ineffective or has been omitted
6 Failure to obtain narcosis—this results because the solution is expelled or there has been underdosage

ETHER IN OIL RECTALLY ADMINISTERED

Definition Analgesia, or anesthesia, depending upon dose and state of subject, produced by the rectal instillation of ethyl ether in oil

Uses

1 For analgesia or anesthesia for surgery (superficial operations)
2 For analgesia in obstetrics
3 For relief of "status asthmaticus"

Cost The ether oil technique is inexpensive

Materials The utensils and instruments listed for avertin are satisfactory for ether and oil

1 Ether (U S P for anesthesia)
2 Olive, cottonseed, or other bland vegetable oil
3 Rectal catheter, 16–20 French
4 A glass funnel approximately 2 inches in diameter with a stem which fits into catheter
5 One graduated syringe (10 cc) to measure ether and oil
6 A pharyngeal airway and tongue depressor
7 A clamp for the catheter
8 Anesthesia apparatus with inhaler for resuscitation and rebreathing

Dosage for Adults

1 3/4 to 1 cc ether per pound of body weight The usual preparations consist of a mixture of 50 to 65% ether in bland oil (1 cc ether 1 cc oil to 1 cc ether 1/2 cc oil)
2 Use the lower limit of the dose except for obese, large subjects
3 Do not exceed 160 cc ether, regardless of the weight of the patient

Premedication

1 Paraldehyde, 7 5 cc to 15 cc in an equal volume of oil by rectum, one hour prior to administration of ether (use technique described below for premedication)
2 Morphine sulphate, gr 1/6 to 1/4; Atropine or scopolamine, 1/150 to 1/100 } one hour prior to administration of ether
3 Cleansing enema 3 to 4 hours prior to instillation (as for avertin)

Procedure Follow the routine described for avertin

1 Instill the mixture 20 minutes before hypnosis is desired
2 Place patient in Sim's position or on left side
3 Lubricate the anus and surrounding skin with vaseline to prevent irritation

Materials

1. Large syringe (20–30 cc) of the bulb type or one with long nipple
2. Rectal catheter of desired size (14–18F) which attaches to syringe
3. Lubricant
4. 2 strips of adhesive for strapping buttocks together
5. Clamp or artery forceps for catheter
6. Pentothal for rectal use
7. Distilled water or normal saline

Preparation of Patient

1. Cleanse colon with a saline enema at least 6 hours before induction time (night before preferable)
2. Administer scopolamine, hyoscyamine or atropine in proper dosage (see premedication)

Dosage

a. Heavy basal narcosis—1 gm for each 50 lbs of body weight
b. Light basal narcosis—1 gm per 75 lbs body weight
c. Hypnosis—1 gm per 100 lbs body weight

Procedure

1. Dissolve pentothal in water warmed about body temperature to make a 10% solution Draw into syringe
2. Attach catheter to syringe and lubricate tip
3. Turn patient on left side and insert catheter 4 or 5 inches into the rectum
4. Instill solution as fast as patient tolerates it
5. Draw small amount of saline or water into syringe and force into catheter to wash out solution remaining in catheter into rectum
6. Clamp catheter and remove syringe
7. Strap buttocks together to help retain catheter in place

Onset of Action

1. Within 5 minutes Peak attained in 15 minutes

Duration

1. About one hour

Advantages

1. Does not irritate the mucosa
2. Precipitation due to cooling does not occur (with avertin it does)
3. Duration of basal narcosis longer than by intravenous route

Comment	*Reasons*
1 Do not warm the solution	Ether is highly volatile and passes off
2 Prepare the solution at the time of injection	This precludes the possibility of irritation from decomposed ether
3 Do not omit premedication	Salivation, mucus formation, and excitement are common without it
4 Always have an inhaler available for instant use	Overdosage may readily occur in such an uncontrollable technique
5 Employ the 65% solution for rapid induction and more intense narcosis	The absorption of ether is retarded by the oil

ETHER OIL IN OBSTETRICS

Premedication Pentobarbital, three grains orally at onset of pain

Dosage

Ether, 60 cc (2 oz)
Paraldehyde, 7 5 cc (0 25 oz)
Olive oil, 120 cc (4 oz)

Technique Same as above

Comment

1 Be sure catheter passes beyond presenting part of fetus
2 Repeat every several hours if necessary
3 Supplement by inhalation anesthesia if necessary

REFERENCES

Gwathmey, J T *Ether Oil Anesthesia* Lancet, *2* 1756–1758 December, 1913
Gwathmey J T Obstetrical Analgesia Surg Gyn Obs *51* 190 August 1930

RECTAL PENTOTHAL

Definition Basal narcosis by the rectal instillation of an aqueous solution of sodium pentothal

Uses

1 As a preliminary to surgical anesthesia for children and other subjects in whom intravenous administration of drugs is not feasible
2 To control convulsive states
3 To perform diagnostic and non painful minor procedures such as X-ray examinations, endoscopic examinations, etc

Materials

1. Large syringe (20–30 cc) of the bulb type or one with long nipple
2. Rectal catheter of desired size (14–18F) which attaches to syringe
3. Lubricant
4. 2 strips of adhesive for strapping buttocks together
5. Clamp or artery forceps for catheter
6. Pentothal for rectal use
7. Distilled water or normal saline

Preparation of Patient

1. Cleanse colon with a saline enema at least 6 hours before induction time (night before preferable)
2. Administer scopolamine, hyoscyamine or atropine in proper dosage (see premedication)

Dosage

a. Heavy basal narcosis—1 gm for each 50 lbs of body weight
b. Light basal narcosis—1 gm per 75 lbs body weight
c. Hypnosis—1 gm per 100 lbs body weight

Procedure

1. Dissolve pentothal in water warmed about body temperature to make a 10% solution Draw into syringe
2. Attach catheter to syringe and lubricate tip
3. Turn patient on left side and insert catheter 4 or 5 inches into the rectum
4. Instill solution as fast as patient tolerates it
5. Draw small amount of saline or water into syringe and force into catheter to wash out solution remaining in catheter into rectum
6. Clamp catheter and remove syringe
7. Strap buttocks together to help retain catheter in place

Onset of Action

1. Within 5 minutes Peak attained in 15 minutes

Duration

1. About one hour

Advantages

1. Does not irritate the mucosa
2. Precipitation due to cooling does not occur (with avertin it does)
3. Duration of basal narcosis longer than by intravenous route

4 May be administered at bedside
5 Induces amnesia and hypnosis without excitement
6 Reduces post anesthetic nausea and vomiting
7 Permits use of drug when intravenous route is not feasible
8 May be used in infants and children

Disadvantages

1 May cause respiratory depression
2 Response variable due to variation in individual tolerance
3 Laryngeal spasm may occur
4 Patient rouses when stimulated unduly

Contra-Indications

1 Conditions characterized by respiratory depression, dyspnea, pulmonary insufficiency or obstruction
2 Suppurative diseases of the respiratory tract with secretions Spasm results
3 Cardiac diseases with decompensation
4 Hypotensive states particularly if due to reduced blood volume
5 Renal disease with insufficiency
6 Dehydration with electrolyte disturbances
7 Anemia of sufficient degree to reduce oxygen carrying power of blood
8 Inflammatory diseases of the rectum
9 As a sole anesthetic agent for procedures in which painful stimulation occurs
10 Debilitated subjects and subjects in older age groups

Comment	*Reason*
1 Follow precautions listed under avertin	Basic principles of rectal anesthesia are same for all drugs
2 Omit enema if time of administration is less than 5–6 hours prior to anesthesia	Stasis of fluid dilutes solution and inhibits proper absorption of drug
3 Use saline for enema	Soap irritates mucosa Fluid may be retained for sometime after enema
4 Do not exceed a total of three grams	Overdosage may occur
5 Have ephedrine, metrazol or picrotoxin available	These are effective in combating respiratory and circulatory depression
6 Do not introduce artificial airways unless absolutely necessary during basal narcosis	Laryngeal spasm may result

7 Reduce dose for states characterized by low metabolic rate	Such patients are less tolerant to non volatile drugs
8 Omit narcotics for premedication in children	Respiratory depression may occur
9 Non sterile tap water may be used to prepare solution	Satisfactory if distilled water is not available
10 Administer only to fasting patients	Vomiting and aspiration may occur if patient has full stomach
11 Although more concentrated solutions are preferred solutions as dilute as 2% may be used	Large volume is chief objection to dilute solution

RECTAL EVIPAL

Follow same procedure as that described for rectal pentothal using same dose and concentration

RECTAL SURITAL

Follow same procedure as that described for rectal pentothal using same dose and concentration

PART VI

REGIONAL ANESTHESIA

GENERAL CONSIDERATIONS OF REGIONAL ANESTHESIA

Definition

Anesthesia produced by applying a drug at a point along the course of a nerve and abolishing conduction of afferent and efferent impulses through the segment affected

Synonyms

Conduction anesthesia, block anesthesia

Types

Regional anesthesia is subdivided into various types classified according to the site of application of the drug (Fig 96)

1 *Spinal* The spinal nerves are blocked at the anterior and posterior roots in the subarachnoid space (Fig 96A)
2 *Epidural* The spinal nerves are blocked in the epidural space (Fig 96B) after acquiring a dural sheath
3 *Paravertebral* The spinal nerves are blocked as they emerge from the intervertebral foramina, or in the vicinity of the vertebrae (Fig 96C)
4 *Nerve* The somatic nerves are blocked at some point along their course to the periphery of the body before they divide into their terminal branches (Fig 96D)
5 *Field* The large terminal branches are blocked by injecting a wall of local anesthetic drug at the border of the area they supply just as they branch (Fig 96E)
6 *Topical* } The nerve endings are anesthetized by injecting
7 *Infiltration* } or spreading the drug in the area they supply (Fig 96F)

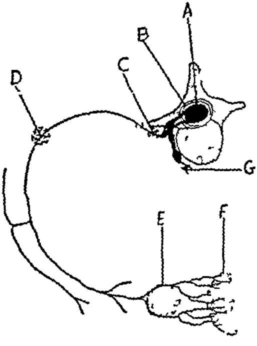


Fig 96 Types of regional blocks (A) Subarachnoid or spinal (B) Epidural (C) Paravertebral (D) Nerve block (E) Field block (F) Infiltration (G) Sympathetic block Note that in field block the nerves are anesthetized as they divide into terminal branches In infiltration, and topical the nerve endings are anesthetized

Local Anesthetic Drugs

Although numerous local anesthetic drugs have been prepared and are in use, all in current use possess certain common physical, chemical, and physiological properties The most important of these may be summarized as follows

Physical and Chemical Properties

1 They are synthetic substances (except cocaine)
2 They are basic substances possessing complex molecular structures The majority are amines Most of them are esters
3 They form salts with mineral and organic acids The salts of hydrochloric acid are the most common The salt is more stable and soluble in water than the free base Aqueous solutions of salts are acid in reaction (pH 6±)
4 The base is more soluble in oils and other lipoids Aqueous solutions are alkaline The free base is easily precipitated by alkalis from aqueous solutions of salts
5 They are incompatible with salts of mercury, silver, and other metals

Physiological Properties

1 The critical effective concentration of a drug which penetrates a nerve is higher than the blood concentration which gives rise to toxic manifestations Consequently, the drug must be localized in as small an area and as close to the nerve as possible to prevent systemic absorption and toxic reactions
2 Excessive amounts in the systemic circulation give rise to toxic reactions manifested by circulatory collapse or central nervous system stimulation
3 Toxic reactions occur when the rate of absorption exceeds the rate of elimination or detoxification A large amount slowly absorbed may produce a less severe reaction than a small amount quickly absorbed or intravenously administered The response obtained varies with blood levels
4 Systemically small amounts are violent central nervous system stimulants or cardiac depressants, large amounts are profound central nervous system depressants and cause paralysis Sedative drugs, particularly the barbiturates, antagonize the stimulation of the nervous system but do not protect the heart
5 The duration of action, local tissue reactions, and effect upon various components of the nervous system vary with and are dependent upon

TABLE X

CURRENTLY EMPLOYED LOCAL ANESTHETIC DRUGS

Name	*Synonym*	*Salt*	*Use*				
			Spinal Block	*Epidural Block*	*Nerve Block*	*Field Block and Infiltration*	*Topical*
Procaine U.S.P.	Neocaine Novocaine	Hydrochloride	Widely employed 50–150 mg	Recommended 50 cc 2%	Widely employed 50 cc 2%	Widely employed 100 cc 1%	Possesses no action
Cocaine U.S.P.		Hydrochloride	Not employed	Not employed	Not employed	Not employed	Useful (with caution!) 4%
Pontocaine N.N.R.	Tetracaine U.S.P. Pantocaine	Hydrochloride	Widely employed 5–20 mgm	Employed 50 cc 0.10%	Employed with caution 75 cc 0.10%	Not employed 100 cc of 0.1%	Useful (with caution!) 2%
Nupercaine N.N.R.	Percaine Dibucaine	Hydrochloride	Widely employed 2½–15 mgm	Not employed	Not recommended 0.1%	Not recommended 0.05–0.1%	Useful (with caution!)
Butyn U.S.P.	Butacaine	Sulphate	Not employed	Not employed	Not employed	Not employed	Useful 2%
Metycaine N.N.R.	Neothesine Piperocaine	Hydrochloride	Widely employed 75–125 mgm	Widely employed 50 cc 1.5%	Widely employed 50 cc 1.5%	Widely employed 75 cc 1%	Useful 3%
Benzocaine U.S.P.	Anesthesin	Not employed	Ineffective	Ineffective	Ineffective	Ineffective	Useful 5%
Benzyl Alcohol N.N.R.		None	Not useful	Not useful	Not useful	Not useful	Useful 4%
Monocaine		Formate	Recommended 50–100 mgm	Useful 1.5%	Useful 1%	Useful 1%	Not employed
Intracaine		Hydrochloride	Useful 50–100 mgm	Useful 1%	Useful 1.5%	Useful 1%	Not employed
Apothesene N.N.R.		Hydrochloride	Useful	Not employed	Useful 1%	Useful 0.5%	Not useful
Diothane N.N.R.		Hydrochloride	Not employed	Not employed	Not employed	Useful 0.5%	Recommended 1%
Butesin		Picrate	Not employed	Not employed	Not employed	Not employed	Useful
Lidocaine N.N.R.	Xylocaine	Hydrochloride	Not employed	2% 25–35 cc	30 cc 2%	50 cc 1%	5%
Hexylcaine	Cyclaine	Hydrochloride	20–50 mgm	2% 25–35 cc	30 cc 2%	50 cc 1%	5%
Peridocaine	Lucaine	Hydrochloride	50–100		2%	1%	

the chemical nature of the drug The properties vary from drug to drug

6 Each possesses a latent period which varies with the chemical nature of the drug and the concentration Time interval between moment of application of drug on nerve until blockade is completely established is greater for longer lasting drugs as a rule
7 They are potentiated by proteins, potassium ion, xanthines and numerous other substances
8 The action is reversible The conduction in the nerve fibre is restored to normal when the drug is removed or eliminated
9 They are detoxified by the liver The more easily and quickly they are detoxified the less toxic the drug
10 The effective concentration varies with the size of nerve fibre Sensory fibres are smaller and affected before motor fibres Stronger concentrations are necessary for penetration into sheathed and myelinated fibres

The comparative toxicity and potency of local anesthetic drugs are difficult to establish because these factors not only vary from one species to the next, but also with the mode of administration, rate of administration, concentration employed, and rate of absorption within a given species

Characteristics of a Suitable Anesthetic Drug

1 Onset of action should be rapid, consuming not more than a few minutes
2 Duration of action should allow sufficient time to complete the operation
3 There should be freedom from local irritation to the nerves or tissues
4 Systemic toxicity should be low
5 The drug should be soluble in water
6 The drug should be stable and boilable
7 It should be compatible with vasoconstrictors and with components of tissue fluid

Approximate values for toxicity and potency of some common drugs (cocaine = 1)

TABLE XI

Drug	*Toxicity*	*Potency*
Cocaine Hydrochloride	1	1
Procaine Hydrochloride	¼	⅓
Metycaine Hydrochloride	¼	¼
Pontocaine Hydrochloride	3	2
Butyn Sulphate	¾	[illegible]
Nupercaine Hydrochloride	3 to 5	2½

Use of Procaine in Regional Anesthesia

Procaine hydrochloride is the least toxic and most useful of all the local anesthetic drugs, and, therefore, the drug of choice The duration of action averages approximately one hour The hydrochloride is dissolved in aqueous physiological saline or distilled water

TABLE XII

Concentration	*Uses*	*Maximum Amount*	*Average Dose*
0 5%	Infiltration, skin wheals subcutaneous injection	225 cc	200 cc
1 0%	Infiltration field blocks	125 cc	100 cc
2 0%	Nerve epidural and para vertebral blocks	60 cc	50 cc
5 0%	Spinal anesthesia	4 cc	2 cc
10 0%	Spinal anesthesia	2 cc	1 5 cc

Comment

1 Decrease the dose for debilitated, cachetic, or aged subjects
2 Boil sterile physiological saline, add the desired weight of procaine hydrochloride crystals, and boil three minutes longer to prepare a sterilized solution of the drug

TABLE XIII
Comparative Dosage of Local Anesthetics

	CC s of Drug Equivalent to 1 cc Procaine			
Procaine Maximum Volume	2% 50 cc	1% 100 cc	5% 200 cc	25% 400 cc
Pontocaine	15% 1 cc	1% 1 cc	05% 1 cc	02% 1 cc
Metycaine	1 5% 1 cc	75% 1 cc	50% 1 cc	25% 1 cc
Xylocaine	2% ½ to 1 cc	1% ½ to 1 cc	5% ½ to 1 cc	25% ½ to 1 cc
Intracaine	2% ¾–1 cc	1% ¾–1 cc	5% ¾–1 cc	25% ¾–1 cc
Cyclaine	2% ¾ cc	1% ¾ cc	5% ¾ cc	25% ¾ cc
Monocaine	2% ¾ cc	1% ¾ cc	5% ¾ cc	25% ¾ cc

Use of Vasoconstrictor Drugs in Regional Anesthesia

Purpose

1 To produce local vasoconstriction for the prevention of rapid absorption of local anesthetic drugs Toxicity is decreased and the action is prolonged thereby

2 To overcome hypotension caused by vasomotor disturbances resulting from regional anesthesia

Drugs available The sympathomimetic amines are the most useful vasopressor drugs *For infiltration*, epinephrine and cobefrin are preferred *For hypotension*, ephedrine, neosynephrine, epinephrine, oenethyl, methedrine, and mixtures of pituitrin and ephedrine are employed

Uses

1 To prolong anesthesia

Epinephrine a stock solution, 1 1000 (U S P), is added to the local anesthetic solution The dilution employed varies from 1/10,000 to 1/100,000, depending upon the physiological status of the patient and the preference of the surgeon Usually 1 100,000 is ample

Cobefrin 1/200 is diluted to 1/1000 to 1/10,000 Cobefrin is less pronounced in its action than epinephrine and produces less systemic disturbances

2 To relieve hypotension See spinal anesthesia

Indications

1 When injection of local anesthetic drug is made into highly vascular areas (scalp, genitalia, etc)
2 When concentrated solutions of anesthetic drugs are employed
3 When local anesthetic drugs of relatively high toxicity are employed

Contra Indications

a When hypertension or cardiac disease exists
b If the subject is emotionally disturbed (thyrotoxicosis)
c For anesthesia of the extremities, particularly if peripheral vascular disease is present
d In obstetrics—labor may be delayed by use of epinephrine
e During combined local and inhalation anesthesia, particularly if cyclo propane, chloroform, or ethyl chloride are employed

Overdosage or Toxic Reaction of Local Anesthetic Drugs

Causes of Overdosage

1 Accidental intravascular injection of a drug
2 Injection of excessive quantities of the drug at one single time
3 Injection of a concentrated stock solution through error
4 Injection of a solution into highly vascular areas without the addition of vasoconstrictor substances
5 Use of highly toxic drugs or drugs whose margin of safety is narrow
6 Topical application of excessive quantities or concentrated solutions to mucous membranes

7 Use of average quantities in subjects who are debilitated, cachetic, or otherwise possess an impaired detoxifying mechanism

Types of Reactions

Two types of systemic reactions from local anesthetic drugs are recognized neurological or stimulating and circulatory or depressant types

1 *Neurological type*

Cause If local anesthetic drugs gain access to the systemic circulation they cause intense stimulation of the nervous system If the dose is large or stimulation is prolonged, depression follows The reaction may be divided into an early or stimulating phase and a delayed or depressed phase The most common symptoms are those which occur in the following physiological systems

TABLE XIV

Phase	*Central Nervous System*	*Circulatory System*	*Respiratory System*
Early part of stimulating phase	Excitement apprehension or other symptoms of emotional instability Sudden headache Nausea or vomiting Twitchings of small muscles particularly of face finger etc.	Pulse varies slowing of pulse more common than an increase Either an elevation or fall in blood pressure but a change does occur Pallor of skin	Increased respiratory rate and depth
Advanced part of stimulation phase	Convulsions	An increase in both blood pressure and pulse rate	Cyanosis dyspnea and rapid respiration
Depressed phase	Paralysis of muscles Loss of reflexes Unconsciousness	Circulatory failure No palpable pulse	Respiratory failure Ashen grey cyanosis

Treatment

1 Inhalation of oxygen If respiratory movements have failed, inflate the thorax by use of the mask and bag or other suitable method of artificial respiration

2 Inject a barbiturate intravenously Any barbiturate is suitable, but an ultra-short acting drug such as pentothal or evipal is preferred Observe the following precautions

a Inject enough drug to control the convulsions

b Start injection as soon as possible

c Support the airway and administer oxygen or artificially respire the patient if respiratory failure ensues

Prophylaxis

1 Always administer a therapeutic dose of a barbiturate in addition to other premedication when contemplating the use of a local anesthetic drug

2 Add epinephrine or some other suitable vasoconstrictor substance to solutions when anesthetizing vascular areas, such as the scalp, neck, perineum, etc
3 Use the weakest effective solution of the selected drug
4 Measure or weigh accurately all solutions or drugs employed
5 Label stock solutions plainly or color them so that they are easily identified and not confused with dilute solutions
6 Aspirate before injecting any solution

Comment

1 An assistant trained in anesthesia should observe and record blood pressure, pulse, and respiratory rate throughout all operations performed with regional anesthesia
2 An apparatus for administration of oxygen and artificial respiration should always be instantly available for all patients receiving local anesthetic drugs
3 A soluble barbiturate and sterile equipment for intravenous administration should be available for immediate use when any local anesthetic drug is used for any purpose
4 Immediately terminate injection of any local anesthetic drug if any untoward symptoms appear
5 Never diagnose an apprehension which appears during administration of local anesthetic drugs as "hysteria"

2 *Circulatory or depressant type*

Cause The local anesthetic drug, even after the injection of minute amounts, produces syncope and circulatory failure by myocardial depression or vasodilatation or both This reaction has frequently been termed an idiosyncrasy However, it may occur after the use of therapeutic amounts of the agent Two types may be differentiated, the immediate and the delayed The symptoms are as follows

Immediate type

1 Pallor
2 Tachycardia, occasionally bradycardia or arrhythmia
3 Sudden collapse characterized by hypotension and low pulse pressure
4 Reaction on skin in area of injection

Delayed

1 Progressive drowsiness
2 Hypotension—feeble, slow pulse

Treatment

1 Prone position, lower head

2 Artificial respiration with oxygen by any method which is instantly available
3 Vasoconstrictors (ephedrine, epinephrine, neosynephrin, etc) if hypo tension is present
4 Open thorax and perform cardiac massage if asystole has occurred—without delay Inject epinephrine into the right auricle (0 25 cc 1/1000)

Prophylaxis

1 Never inject a local anesthetic drug into a patient who presents a his tory of sensitiveness or idiosyncrasy to a drug without investigating the claim
2 Perform a skin and intranasal test with the drug before it is employed

Comment

1 Barbiturates are ineffective in the circulatory type of drug reaction
2 Accidents frequently occur after injections of small amounts of drugs
3 Onset is sudden and without warning Treatment is usually ineffective, with disappointing results
4 Local anesthetics depress cardiac tissue
5 More frequent in debilitated, cachetic and aged subjects

Substances Used to Prolong Anesthesia

Absolute Alcohol

Mode of Action

Causes destruction of nerve tissue Attacks smaller nerve fibers with greater ease than large resulting in greater sensory than motor loss in mixed nerve

Dosage

An area of necrosis 1 cm in diameter results from injection of 5 cc into soft tissues Average dose 2 to 3 cc for each nerve trunk to be injected Ab solute alcohol must be used from a dry syringe

Duration

One to six months or longer

Objectionable Features

a Painful neuritis frequently follows its use
b Abstracts water from tissues and becomes diluted, producing an in complete block

c Does not yield satisfactory block unless needle is in direct contact with nerve or ganglion to be blocked
d Results not satisfactory if injected after a block using aqueous solution of local anesthetic because of dilution factor
e Duration of block variable because nerve regenerates

Benzyl Alcohol

Mode of Action

Causes anesthesia and degeneration of nerve fibres Usually combined with procaine, benzocaine and other local anesthetic drugs Not ordinarily used alone

Bromsalizol

Mode of Action

Causes a blockade and some degeneration of nerve fibres by sclerosing action Usually dispensed in a concentration of 4% in peanut oil

Dosage

Usually 5 cc at each nerve trunk

Duration of Action

Several days to several weeks Very variable

Local Anesthetics in Oil

Bases of procaine, nupercaine, intracaine are prepared in oily solutions, combined with benzyl alcohol, anesthesin, phenol, etc

Mode of Action

Slow release of the agent into the tissue from oil which tends to withhold the drug Yields prolonged effect Also some nerve destruction

Dosage

Procaine 5 cc 2%
Nupercaine 5 cc 0 2%
Intracaine 5 cc 2%

Ammonium Sulphate

Mode of Action

Is alleged to cause a selective degeneration of C type of sensory fibre, which carries diffuse deep, dull pain impulses

Dosage

Usually used in combination with benzyl alcohol (Dolamin NH_4SO_4 0 75%

Benzyl alcohol 0 75% NaCl 45%) The volume of Dolamin used equals the volume of procaine injected to induce the block

Duration of Action

Very variable No effect in many cases One day to six weeks duration may be expected

Phenol—6%

Mode of Action

Like alcohol

Dosage

5 cc per nerve trunk

Duration of Action

Like alcohol

Materials Required for Nerve and Field Blocks and for Infiltration Anesthesia (Fig 97)

1 Two wheal needles (½ cm long, of 24 or 25 gauge)
2 Ether and skin sterilizer, for preparing skin
3 Sponge forceps and sponges for preparing skin
4 Six sterile towels for draping operative field
5 Four sterile towel clamps
6 Ten cc syringe for regional anesthesia equipped with a lock (Fig 98)
7 Needles—10 cm 20 gauge
8 cm 22 gauge
5 cm 20 or 22 gauge
8 0 5% procaine solution for skin wheals
9 Procaine or other desired drug in necessary amount
10 Sterile container, 250 cc or 500 cc, preferably of glass or enamel, for reservoir for solution of local agent
11 Epinephrine solution (1 1000 U S P)
12 Physiological saline for drug which is to be diluted, or for testing needles
13 Several squares of rubber (5 mm × 5 mm) cut from rubber tubing, which are to be used for markers (Fig 102, page 323)
14 Gloves and powder
15 Metal ruler (sterilized)
16 India ink or other marking substance which will not dissolve in ether or skin sterilizers
17 Short acting barbiturate and sterile apparatus for administering the same in the event of overdosage or toxic reactions
18 Inhaler for artificial respiration

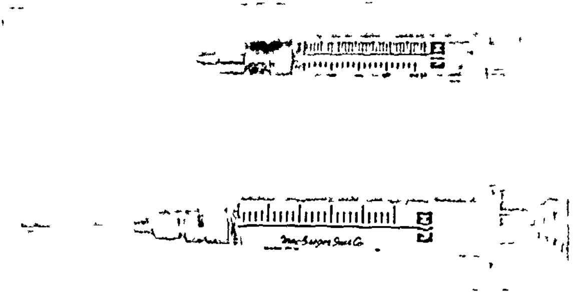


FIG 98 Syringes used for regional anesthesia The lock type of syringe is preferable for ease in handling and to avoid leakage about the hub of the needle

Comment

1 Arrange the above instruments upon a tray approximately 12 inches by 18 or 20 inches Wrap and have in readiness for use (Fig 99)
2 The number of needles necessary varies with the type of block to be performed Two of each are desirable if available
3 Syringes and needles may be of any type, but those designed exclusively for regional anesthesia are preferred

TESTING FOR SENSITIVITY TO A LOCAL ANESTHETIC DRUG

Object

To determine whether or not the patient has an idiosyncrasy to the drug which is to be employed

Materials for Skin Test

1 Local anesthetic drug to be tested
2 Wheal needle and a small syringe
3 Physiological saline solution
4 Seventy per cent alcohol
5 Ether
6 Sponges

Procedure

1 Cleanse skin on anterior surface of one of the forearms with ether and sterilize with alcohol
2 Raise a small intradermal wheal approximately 5 mm in diameter with saline solution

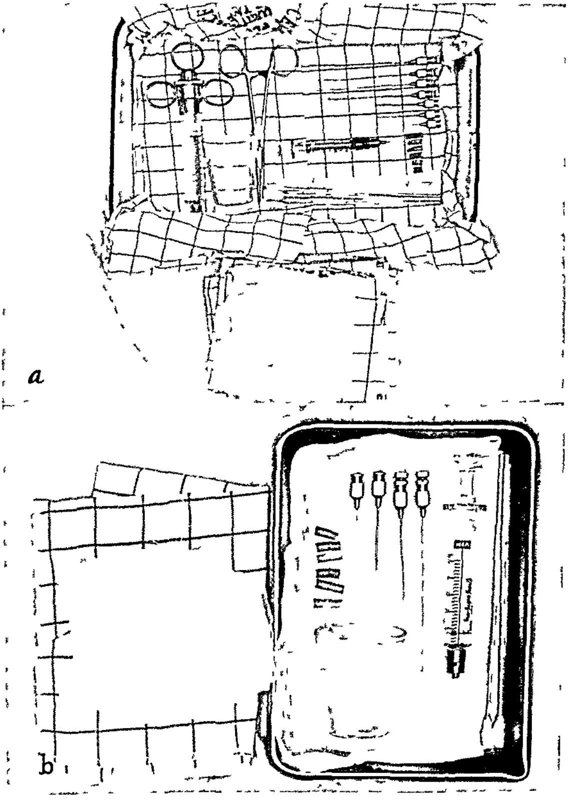


FIG 98 Assembly for regional anesthesia (a) Large set for multiple nerve blocks (b) Small set to be used for single nerve blocks

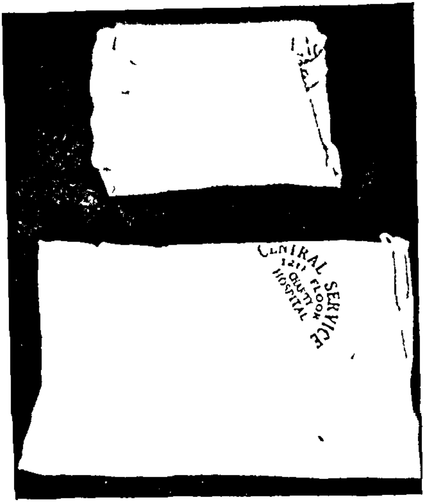


FIG 99 Assembly wrapped and ready for use The instruments are packed in a tray and wrapped and sterilized by autoclaving and kept in readiness for use

3 Raise a similar wheal 3 or 4 cm from this area using the local anesthetic drug to be tested

Comment

1 After 5 minutes, if both wheals appear to be alike the test is negative, if the wheal produced by the drug is red and spreads over a wide area the test is most likely positive and the drug should not be employed
2 A negative response is not assurance of tolerance

INTRANASAL TEST

Materials

1 Sphygmomanometer
2 Several cubic centimeters of solution to be employed

Procedure

1 Apply sphygmomanometer to arm and record blood pressures at 3 minute intervals until stabilized

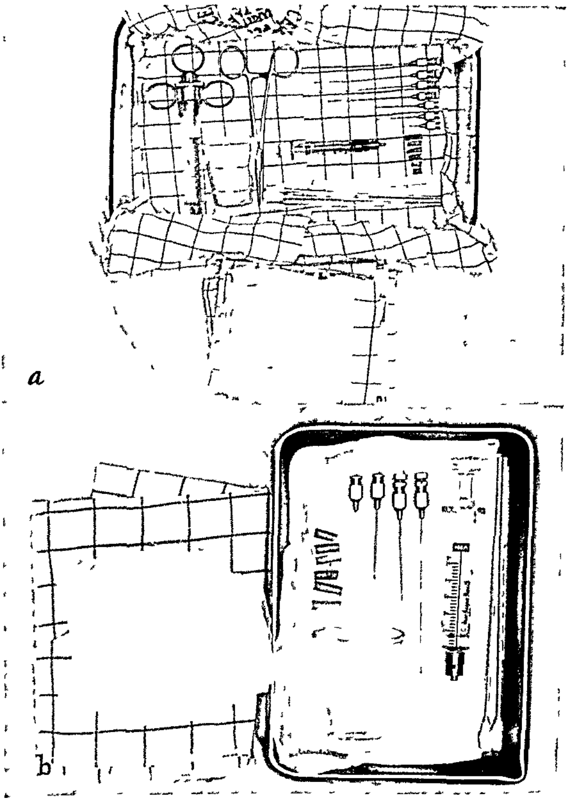


FIG 98 Assembly for regional anesthesia (a) Large set for multiple nerve blocks (b) Small set to be used for single nerve blocks

2 Always insert a needle in a direction normal to the skin

3 Do not connect the syringe to the needle until the needle is properly placed, unless so specified

The weight of syringe and leverage exerted obliterates sense of direction transmitted to fingers if only the needle is used

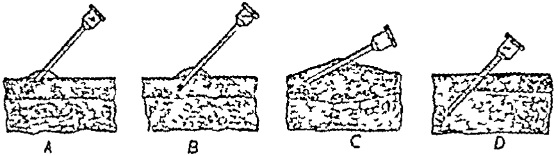


FIG 100 Method of raising an intradermal wheal (A) The needle is introduced with bevel down through a drop of procaine until it pierces the skin (B) The needle is then rotated and enough of the drug injected *intradermally* to form a (C) blanched area with an orange peel appearance Incorrect method of raising a wheal is shown in (D) The needle should not be introduced into the subcutaneous areas

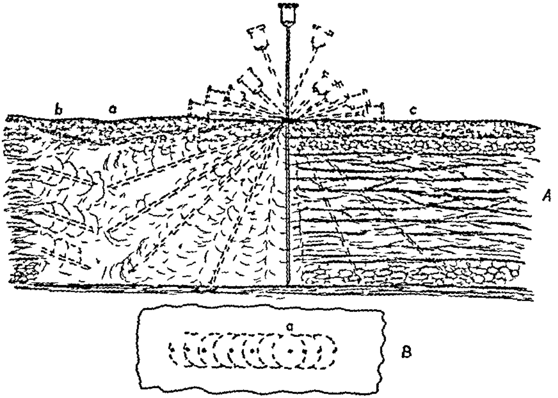


FIG 101 (A) Method of performing fanwise infiltration for field blocks (a) Shows the solution infiltrating the tissues as the needle is advanced (b) Shows the overlapping of the solution from the injection made through the adjacent wheal so that a continuous wall of solution is thrown into the tissues (c) Shows needle penetrating all layers of tissues

(B) Method of raising a continuous intradermal wheal The wheal is first raised at point *a* the needle is then introduced at the periphery on each side and a succession of wheals is thus produced The needle point should always be thrust into the anesthetized area after the first wheal is raised A continuous intradermal wheal around a limb is known as a "garter band"

2 Record pulse until stabilized
3 Introduce one drop of the solution to be tested into each nostril with patient in supine position
4 After three minutes introduce two drops into each nostril and note pulse and blood pressure
5 After three minutes more introduce 4 drops into each nostril and note pulse and blood pressure
6 Observe blood pressure and pulse every 3 minutes for next 15 minutes Neither a slowing or acceleration of the pulse nor an elevation or depression of blood pressure should occur Look for tremors also

Comment

Sensitivity to drug will be manifest by significant lowering of blood pressure and alterations of pulse rate

1 Intolerance is not an allergic type of response resulting from an allergen antibody interaction
2 The nasal test should always supplement the skin test
3 The nasal test when positive indicates effects resulting from absorbing drug into blood and therefore is more logical and reliable The skin test is of questionable value

Preparation of Patient

1 For nerve blocks for major surgical procedures
   a Withhold food
   b Morphine gr 1/6—Scopolamine gr 1/150—1½ hours prior to surgery
   c Seconal gr 1½ or pentobarbital gr 1½ or other short acting barbiturate in equivalent dose two hours prior to surgery
2 For nerve blocks for minor surgical procedures
   Seconal or other barbiturate, as above
3 For diagnostic and therapeutic nerve blocks in ambulatory patients
   a If patient is ambulatory and block is simple no premedication is required
   b If patient is apprehensive a barbiturate, as above, may be necessary
   c Withhold food for at least four hours prior to the block

REFERENCE

Adriani John Anesthesia for minor surgery S Clin North America *31* 1507, Oct, 1951

Conduct of Various Aspects of Regional Anesthesia

Comment	*Reason*
1 Always raise an intradermal wheal preliminary to the insertion of a needle through the skin	The skin is the most sensitive structure through which the needle will pass

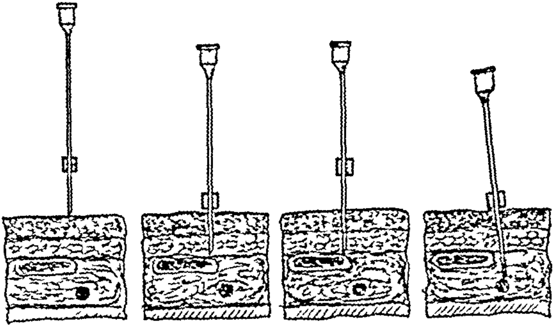


FIG 102 The purpose of a depth marker for introducing a needle into tissues is shown. The marker consists of a piece of cork or rubber which can be moved the length of the shaft of the needle.

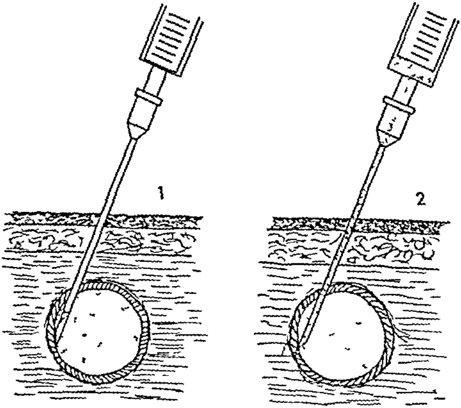


FIG 103 After attempting aspiration rotate needle 180° and attempt aspiration (2) again in event needle bevel had been impinged upon wall of vessel first time (1)

4 Add the desired vasoconstrictor drugs to the local anesthetic solutions at the time the block is performed	Vasoconstrictor drugs are amines and are easily decomposed if allowed to stand for any length of time
5 Do not use discolored solutions of local anesthetic drugs	Decomposition may have occurred and the drug may be ineffective or toxic
6 Advance the needle gently as it approaches a bony landmark	The periosteum is (very) sensitive and the patient may be disturbed from careless manipulations
7 Always attempt aspiration by drawing back on plunger when the needle is placed in the desired location Rotate the needle and repeat so as to aspirate in two planes Withdraw and replace needle in the event blood is aspirated (Fig 103)	This prevents intravascular injections of toxic amounts of the drug
8 Watch patients during injection for signs and symptoms of toxic reactions Injections should be terminated in the event reactions occur	Treatment should be instituted immediately when prodromal signs appear Do not wait until the severe toxic manifestations occur
9 Always perform regional anesthesia under circumstances in which an anesthetic machine is available	The machine is needed for oxygen, artificial respiration, or general anesthesia if the block fails
10 Always have a soluble short acting or ultra short acting barbiturate available together with a sterile syringe and needle and sterile water when using any local anesthetic drug	In the event toxic reactions occur the convulsions may be controlled by the intravenous administration of the sedative
11 Always drape the operative site and maintain absolute sterility	Prevent local infections and abscesses
12 Avoid injections into highly vascular areas or in the region of vascular tissues such as hemangiomas	Rapid absorption or intravascular injection of the local anesthetic may occur
13 Test needles and syringes for patency by passing some solution through them	Needles may be occluded by charred blood, oil, etc
14 Do not overpremedicate patients	Patients will be too drowsy to cooperate with anesthetist

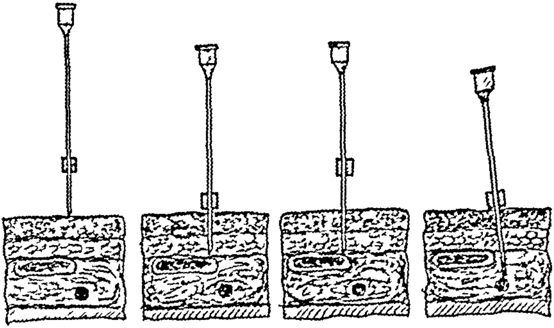


FIG 102 The purpose of a depth marker for introducing a needle into tissues is shown The marker consists of a piece of cork or rubber which can be moved the length of the shaft of the needle

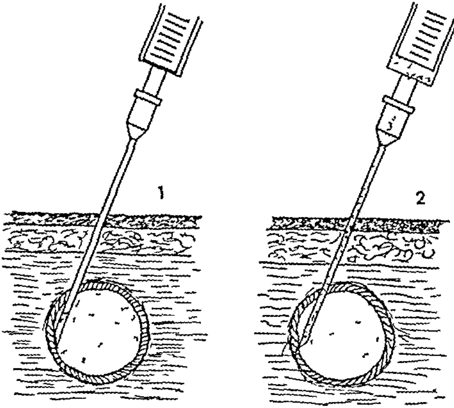


FIG 103 After attempting aspiration rotate needle 180 and attempt aspiration (2) again in event needle bevel had been impinged upon wall of vessel first time (1)

15 Do not omit premedication	Drugs minimize toxic reactions Patients are apprehensive and uncooperative
16 Always warm solutions to body temperature	Onset of anesthesia is delayed or very slow when cold solutions are employed
17 Omit vasoconstrictor drug from local anesthetic solutions in blocks on digits of hands or feet or when cardiovascular and peripheral vascular diseases are present	Vasospasm may be enhanced and gangrene of extremity result Drugs also cause systemic vascular disturbances
18 Never introduce any needle entirely to the hilt or hub	Needles frequently break at the junction of the hub and shaft and are thus difficult to retrieve
19 Avoid piercing nerves or performing intraneural injection	Neuritis may result from intraneural injection
20 *Reject blood stained solutions in* the event blood is aspirated Fill syringe with clear solution	*Proteins of blood may precipitate in* solution
21 Repeat the aspiration test frequently during injection of the drug	The needle point may shift slightly during injection and pass into a vessel
22 Always withdraw the needle as far as the subcutaneous tissues when changing its direction	The needle may be bent or broken, direction is not changed if this is not practiced
23 Always test the area of anesthesia with a blunt needle when the block is completed or before surgery is started	The block may be repeated in event of failure before operative field is prepared
24 Always use a marker as a guide to distance needle is introduced (Fig 102)	Most nerve blocks are "blind" procedures which may result in damage to vital structures if carelessly performed

SPINAL ANESTHESIA

General Considerations of Spinal Anesthesia

Definition

Anesthesia produced by the injection of a solution of a local anesthetic drug into the subarachnoid space A temporary paralysis of the sensory, autonomic, and motor fibers in the anterior and posterior roots emanating from the area bathed by the drug results Block is not caused by the drug's entering the cord proper

Synonyms

Subarachnoid block, spinal analgesia

Types

Spinal anesthesia may be divided into the following types (a) single injection, and (b) continuous

Extent

1 "High Spinal"—anesthesia and analgesia extending above the costal margin accompanied by varying degrees of intercostal muscle paralysis
2 "Medium Spinal" or "Spinal"—anesthesia and analgesia extending above the umbilicus but below the costal margin
3 "Low Spinal"—anesthesia and analgesia not extending above the umbilicus
4 "Saddle"—anesthesia and analgesia confined to the sacral segments only

Uses

1 For surgical anesthesia
2 As an aid to diagnosis of diseases of the autonomic nervous system (megacolon, vasospastic diseases, etc)

Drugs Employed

Although many local anesthetic drugs have been employed with success, the following are currently popular for spinal anesthesia

1 *Procaine* Also called novocaine, neocaine Yields one hour's anesthesia
2 *Pontocaine* Also called pantocaine, tetracaine (U S P) Yields two hour's anesthesia
3 *Nupercaine* Also called percaine, dibucaine Yields three hour's anesthesia
4 *Metycaine* Also called neothesine Yields one to 1½ hour's anesthesia
5 *Monocaine* Yields one hour's anesthesia
6 *Lucaine* Yields ¾ hour's anesthesia

Materials

1 One skin wheal needle, 25 or 26 gauge, ½"-¾" long
2 One spinal needle, 20 gauge, and one spinal needle, 22 gauge, rustless with 45° bevel
3 One short needle, 19 or 20 gauge, approximately 1½"-2" long (Wassermann needle)
4 One syringe, 2 cc , equipped with a lock which fits the various needles in the set

5 One syringe, 5 cc, also equipped with a lock which fits the various needles in the set
6 Two medicine glasses, 2 oz size, for mixing drugs or to act as a reservoir for procaine
7 One per cent procaine, 2 cc sterile ampule, solution for infiltrating skin and interspinous space
8 Several ampules of ephedrine sulphate solution (¾ gr, 50 mgm), or other vasopressor substance
9 One file for opening glass ampules
10 Four sterile towels and towel clips (or special draping sheet with square opening, 6" by 6", in the center)
11 Skin sterilizer

Fig 104 Sealed ampules of local anesthetic drugs for spinal anesthesia

12 Several gauze sponges and one sponge forceps for preparing skin
13 One ampule of the selected drug (optional or varies with technique) (Fig 104)
14 One introducer or Sise guide (Fig 105)
15 Completely equipped anesthesia machine
16 Pillow for supporting the head
17 Sphygmomanometer

Premedication	*Reason*
1 Morphine, grs 1/6 to 1/4, and scopolamine or atropine grs 1/150	In case the block fails and general anesthesia is necessary, the patient will

to 1/100, subcutaneously, one hour prior to induction of anesthesia	be prepared for it Act to sedate patient during operation
2 Therapeutic dose of a short acting barbiturate orally, one hour prior to induction of anesthesia	For counteracting toxic effects of local anesthetic drugs Not absolutely necessary
3 Intramuscular injection of ephedrine sulphate, 3/4 gr, in instances in which hypotension is anticipated (see below)	Vasopressor drugs combat hypotension of spinal anesthesia more effectively than other drugs

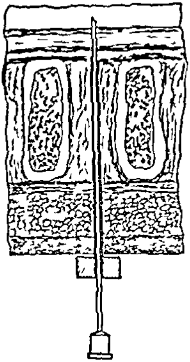


Fig 105 The Sise guide is a trochar designed to facilitate spinal puncture

Preliminary Preparation

1 Apply blood pressure apparatus to right arm
2 Record preliminary reading of tension, pulse rate, and respiratory rate

Position of Patient (Fig 107)

1 Place the patient on his side (lateral prone) with head flexed toward knees and knees flexed on thighs Use upright position for saddle or in obstetrical patients, have assistant hold patient
2 Arrange the patient so that his back is at the edge of the operating table and perpendicular to the floor—upper shoulder should be level with iliac crest (Fig 107)

Preparation of Hands

1 Scrub hands with soap and water or detergent in the same manner as for surgical operation, for at least five minutes
2 Wipe dry and apply sterile rubber gloves

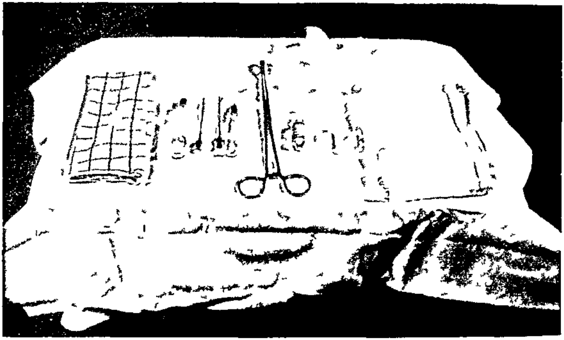


FIG 106 Set up for spinal anesthesia The entire set may be placed in a small tray three or four inches wide and six or eight inches long enclosed in two thick wrappers and sterilized The wrapper may be unfolded and spread over a flat tray providing a sterile set up The sterilized ampules are not included but are added at the time the set up is prepared

Preparation of Skin for Puncture

1 Open ampules of all drugs and test patency of needles and syringes by washing them out with saline solution
2 Mark selected intervertebral space with a blunt pointed instrument
3 Cleanse an area of skin with ether to remove skin lipoids
4 Apply 3½% iodine or other accepted skin sterilizer to skin Wait for sterilizer to act (three minutes) Prepare a large area
5 Remove excess iodine with 70% alcohol

FIG 107 A *The correct position* for the patient in performing spinal punctures The shoulder should be at the level of the iliac crest The surface of the back should be perpendicular to the table The patient should be placed with his back at the edge of the operating table with knees and thighs flexed and head flexed towards the knees

B *The incorrect position* in performing spinal puncture The shoulder is thrown forward the head is extended the vertebral column is twisted

Site of Lumbar Puncture

1 For "High Spinal," 2nd or 3rd lumbar interspace, or any space below, if these are not accessible (an imaginary perpendicular line dropped from the iliac crest passes through 4th lumber space)
2 For "Low Spinal," 3rd and 4th lumbar interspace

Procedure for Lumbar Puncture

1 Raise a skin wheal over the selected site with procaine Use the wheal needle and 2 cc syringe for this purpose
2 Change wheal needle to larger (Wassermann) needle and infiltrate deeper tissues between vertebral spines with procaine
3 Draw ephedrine into 2 cc syringe still attached to Wassermann needle and inject it into muscles lateral to vertebral column Insert the needle through the wheal at a 45° angle to the skin into the muscle

FIGURE 108 The needle is fixed by the left hand when attaching syringes removing or replacing stylet or injecting solutions

4 Insert the Sise guide through the skin wheal into the intraspinous space as far as it will go (optional)
5 Introduce the spinal needle with stylet in place through the guide and into the spinal canal Rotate the needle 180°
6 Attach the 5 cc syringe to the needle and withdraw the desired amount of spinal fluid Replace stylet
7 Attach Wassermann needle, add fluid to the drug in the opened ampule, and draw the solution in and out of the ampule until all crystals are completely dissolved

8 Draw dissolved drug into syringe, remove the stylet, and attach syringe to spinal needle
9 Hold needle firmly with left hand and syringe in right Draw back slightly on plunger and withdraw approximately 0 5 cc of spinal fluid into syringe to determine whether or not there is a free flow of fluid and the needle is still well placed (Fig 108)
10 Inject solution of drug at desired rate (see Individual techniques)
11 After injection again withdraw 0 5 cc of fluid (to ascertain if needle is still in place)
12 Withdraw needle, place dressing over puncture site and place patient in desired position as quickly as possible
13 Establish the desired level of anesthesia (see page 333)

SUBARACHNOID PUNCTURE-INTERLAMINAR (SUBLAMINAR) APPROACH

Uses

When puncture is not feasible by the midline or lateral approach

Materials

Standard spinal set containing 15 cm 20 gauge needle

Procedure

1 Arrange patient in same manner as for classical technique (sitting or lying)
2 Raise wheal 1 5 to 2 cm lateral to midline at 4th or 5th lumbar vertebrae
3 Introduce needle 30-45° to surface of skin medially, cephalad, and anteriorly (Fig 109)
4 As soon as bone is encountered initiate to and fro movement changing angle slightly and advancing until laminar hiatus is reached

Comment

1 The needle enters the subarachnoid space 1 cm higher than the vertebra at which needle enters
2 The course of the needle is determined by the slanting position of the lamina and not the position of the spinous process
3 If done above L-2, cord may be injured

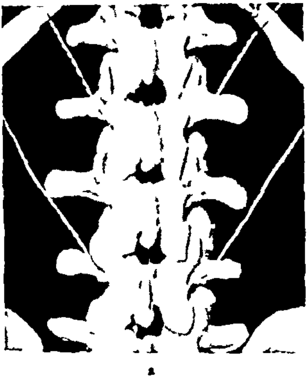
SUBARACHNOID PUNCTURE, LATERAL APPROACH

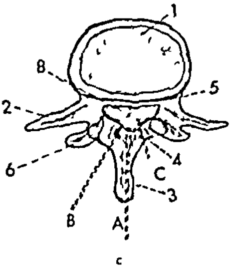
Uses

When the puncture is not feasible by the midline approach

Procedure

1 Mark the center of the interspace with the thumbnail of left hand





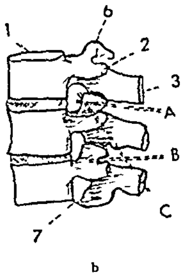


FIG 109 (a) Dorsal view of lumbar vertebrae on mounted skeleton (b) Lateral view of 1st 2nd and 3rd lumbar vertebrae. (c) Top view of second lumbar vertebra A Position of needle in direct or classical approach for lumbar puncture B Lateral approach C Interlaminar approach 1 Body of vertebra 2 Transverse process 3 Dorsal spine 4 Lamina 5 Pedicle 6 Articular process 7 Vertebral notch 8 Spinal canal

2 Raise the wheal 1 5 cms from the midline opposite the center of the interspace
3 Introduce needle (ordinary needle) through the wheal at angle of 25° to midline horizontally with no deviation caudad or cephalad
4 Guide needle *towards midline pointing towards the left thumbnail* which is held there while procedure is being carried out
5 As soon as resistance is encountered (as the needle approaches the ligamentum flavum) the needle is advanced slowly and carefully until it enters the subarachnoid space

Comment

1 The needle lies lateral to the supraspinous and intraspinous ligament
2 When bony resistance is encountered it is due to the vertebral arch The needle may be "worked" *cephalad or caudad until* the ligamentum flavum is encountered
3 Flexion *of the spine is* not required

4 The needle does not have to be directed either cephalad or caudad
5 May be done in prone position

REFERENCES

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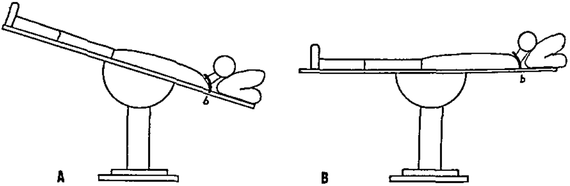
Control of Level and Intensity of Anesthesia

The following six extrinsic factors may be varied to affect level and intensity of anesthesia

1 *Volume of solution injected* This is an important factor The greater the volume of solution prepared with a given weight of drug the higher the level of anesthesia Sensory anesthesia will be more diffuse and motor effort less intense Duration of action slightly shorter This



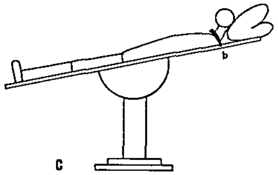


FIG 110 Positions for establishing level of spinal anesthesia when hyperbaric solutions are employed (A) *Trendelenburg position* necessary to secure level of anesthesia for upper abdominal surgery Note the doubled pillow to sharply flex the neck and prevent ascent of drug into the cervical region (B) Position to which patient is returned after level is established in (A) or is placed for anesthesia for lower abdominal surgery (C) Position for low spinal The drug gravitates caudad Note that the shoulders are supported by (b) braces

factor is best maintained constant by employing as small a volume of solution as possible

2 *Rate of injection of fluid* Rapid injection causes drug to ascend into higher levels of the spinal canal Slow injection causes the drug to be deposited and localized at the site of puncture A "Low Spinal" results

3 *Specific gravity of the solution* The specific gravity of spinal fluid averages 1 006 but ranges from 1 003 to 1 009

a If specific gravity of the solution injected is greater than that of spinal fluid, the solution is termed *hyperbaric* Such a solution tends to diffuse downward

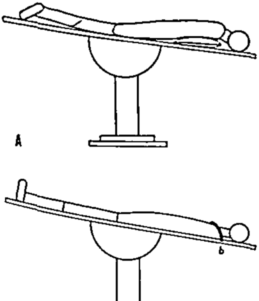
b If specific gravity of the solution approximates that of spinal fluid, the solution is termed *isobaric* *Diffusion of such a solution is not* easy to control and may be upward and downward

c If the specific gravity is less than that of spinal fluid, it is termed hypobaric. Such a solution tends to diffuse upward and bathes posterior roots when the patient is in the prone position

4 *Position of patient after injection* This factor depends upon the specific gravity of the solution employed The object is to prevent the solution from diffusing cephalad into the cervical region

a *Hyperbaric solutions* (Fig 110) For low spinal anesthesia, the patient is placed in a flat or Fowler's position so that the solution gravitates caudad

For high spinal, the Trendelenburg position with head sharply flexed is employed



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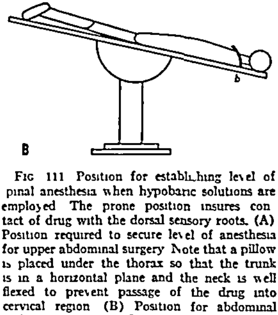

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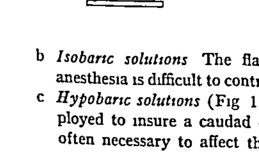

C

FIG 111 Position for establishing level of spinal anesthesia when hypobaric solutions are employed The prone position insures contact of drug with the dorsal sensory roots. (A) Position required to secure level of anesthesia for upper abdominal surgery Note that a pillow is placed under the thorax so that the trunk is in a horizontal plane and the neck is well flexed to prevent passage of the drug into cervical region (B) Position for abdominal and pelvic surgery (C) Position to which the patient is turned from prone to supine after anesthesia is established Note that the shoulders are supported by braces.

b *Isobaric solutions* The flat position is employed The level of anesthesia is difficult to control by varying the position

c *Hypobaric solutions* (Fig 111) The Trendelenburg position is employed to insure a caudad diffusion of the drug Prone position is often necessary to affect the sensory roots (see nupercaine)

5 *Site of injection* This factor has little influence upon the height of "high" spinal anesthesia Injection at lower segments may result in high levels of anesthesia if the rate of injection is rapid or the position of the patient is modified after injection

6 *Dose of drugs* The greater the amount of drug, the higher the level and the greater the intensity of the paralysis The duration of anesthesia is only slightly increased by large doses (Figs 124, 126)

The following intrinsic factors influence the level and intensity of anesthesia, but are not controllable They must be taken into consideration in inducing anesthesia

1 The length of the cord The longer the cord the less intense the anesthesia a given dose of drug will produce
2 The diameter of the cord This factor plays only a minor role unless the subject is unusually large or small
3 The subarachnoid volume The greater the subarachnoid volume the greater the dilution and the less intense will be the anesthesia
4 Curvatures of vertebral column Variations in curvature of lumbar and thoracic portions of the vertebral column may cause pooling of the solution of the drug in thoracic or sacral areas depending upon the specific gravity of the solution and position of the patient after injection of the drug
5 Variations in intraspinal pressure Straining, coughing, deep breathing and labor pains in obstetrics cause changes in spinal fluid pressure which cause cephalad advancement of the drug beyond desired spinal segments

Factors Influencing Duration of Anesthesia

1 *Chemical nature of drug* This is the most important factor which influences duration of anesthesia Others are relatively insignificant

   The average duration of the common drugs is as follows

   Procaine, one hour
   Pontocaine, two hours
   Metycaine, 1½ hours
   Nupercaine, two to three hours

2 *Dose of drug* This influences duration to a certain extent, but not in proportion to increase Large doses provide more intense and extensive anesthesia

3 *Concentration of solution* Concentrated solutions produce more intense anesthesia An increase in duration occurs but not in proportion to the increase in dosage

4 *Vasoconstrictors* See page 311

Intensity of Anesthesia

Intensity of anesthesia refers to the completeness of the block to the passages of impulses in a nerve by the drug It depends upon the following two factors

1 The size of the nerve fibers Sensory and autonomic fibers are smaller than motor Consequently they are more easily and quickly affected
2 Concentration of drug in the solution Dilute solutions affect the smaller nerve fibers more effectively than the large, and produce sensory anesthesia with partial or no motor loss when these fibers are exposed to a given concentration of drug

Advantages of Spinal Anesthesia	*Reasons*
1 It provides excellent muscular relaxation	The reflex arc is interrupted and the muscle is completely paralyzed
2 It is accompanied by little disturbance of metabolic processes	This applies if no hypotension accompanies the anesthesia
3 It dispenses with the inhalation of irritating drugs	Loss of consciousness, secretions, excitement, post anesthetic nausea, and somnolence, as well as other disagreeable features of inhalation anesthesia, are absent
4 It allows use of cautery and electrical appliances	Most inhalation anesthetic drugs are inflammable
5 It is inexpensive in comparison with some anesthetic agents and techniques of administration	The quantity of drug required is one small initial dose
6 May be administered by the operator	The surgeon may serve as anesthetist when an anesthetist is not available

Disadvantages of Spinal Anesthesia	*Reasons*
1 It is noncontrollable	Once anesthesia has been instituted, it cannot be terminated or all deleterious effects combatted
2 Its duration, although usually predictable, is always uncertain	The operation may outlast anesthesia and supplementary anesthesia subjects the patient to the bad effects of two anesthetics
3 The possibility of failure, or technical errors cannot be wholly excluded	Technical difficulties occur even in most skilled hands

4 It is often accompanied by motor paralysis at high levels	This causes respiratory depression or failure from the resulting intercostal paralysis
5 It is often accompanied by distressing circulatory changes	Paralysis of the muscles and autonomic nervous system cause peripheral circulatory failure
6 It is occasionally followed by post operative neurological complications	These may result from the effect of the drug on the cord, trauma from needle infections, etc
7 The patient remains conscious throughout the operation	All patients are not co operative—some are not suited for it
8 The vagal pathways from the viscera are not blocked during abdominal surgery	Retching, nausea, and vomiting follow traction on the viscera
9 Impulses pass into cord above area of block	Retrograde transmission along sympathetic chain can occur

Complications of Spinal Anesthesia Reasons and Treatment

1 *Hypotension* (often called "spinal shock" or primary shock) The degree of shock depends upon the number of segments paralyzed It is usually more pronounced in "high" spinal anesthesia
2 *Characteristics of "spinal shock"*
   a It occurs early during anesthesia It is probably due to sudden relaxation of vascular bed
   b Systolic pressure falls Due to decreased cardiac output (Fig 112)
   c Diastolic pressure is well maintained If it falls, it falls slightly It does not fall in proportion to systolic The peripheral resistance is only slightly decreased Venous and capillary stagnation occur
   d Pulse pressure is decreased Due to decreased cardiac output
   e Circulation time is prolonged Due to decreased cardiac output
   f Bradycardia is more frequently observed when ephedrine or other vasopressor drugs are not used Possibly due to vagal predominance following sympathetic paralysis
   g The blood volume is not reduced, the vascular space is increased
3 *Treatment* Administer a vasopressor drug if the hypotension is severe Any of the following is satisfactory Administer the amount necessary to obtain the desired therapeutic effect
   a *Ephedrine,* gr ¾ (50 mgm), half intravenously, half intramuscularly

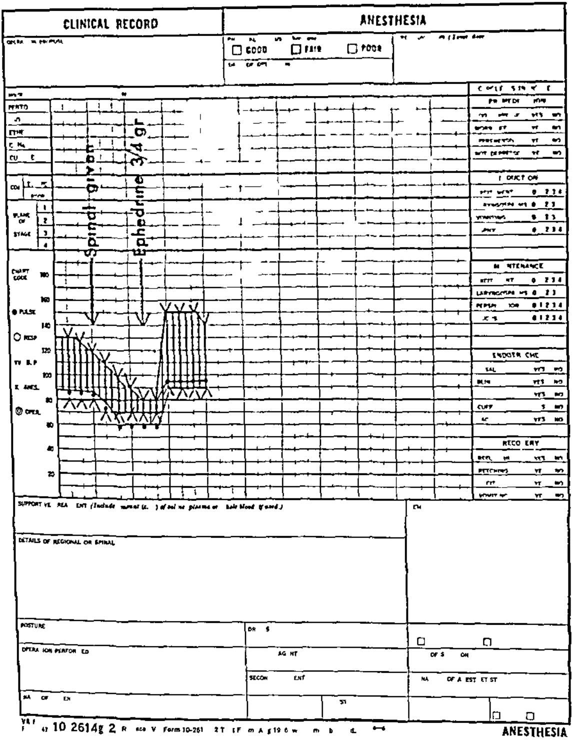

FIG 112 Blood pressure pattern commonly observed during spinal anesthesia Note the marked decrease in systolic blood pressure the comparatively smaller decrease of the diastolic the narrowed pulse pressure and the bradycardia Note the prompt effect of the vasopressor

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3 Diseases of the respiratory system accompanied by a decrease in vital capacity	Intercostal paralysis may decrease tidal exchange and further decrase vital capacity
4 *Anemia* The type matters little The reduction in total hemoglobin is the important factor	The oxygen carrying power of the blood is reduced Anoxia may occur in high spinal if intercostal paralysis is present
5 *Reduction in blood volume* Hemorrhage or operations which may be complicated by hemorrhages Dehydration, shock	Severe hypotension may ensue The compensatory mechanisms which attempt to readjust the vascular system to normal are disturbed by spinal anesthesia
6 *Diseases causing increased intra abdominal pressure* Distension, ascites, pregnancy, ovarian tumors, etc.	These conditions restrain diaphragmatic activity and prevent venous return to the heart contributing further to circulatory failure
7 *Septicemia*	The infecting organisms may be carried into the spinal canal by the needle
8 *Infections about the vertebral column*	The infective organisms may be carried into the spinal canal by the needle
9 *Upper abdominal surgery*	Circulatory disturbances occur frequently during "high spinal" anesthesia The incidence of respiratory complications in the post operative period is high if spinal anesthesia is employed for this type of surgery (10 12%)
10 *Anatomical disturbances of the vertebral column*	The lumbar puncture may be impossible to perform under these circumstances
11 *Psychically disturbed subjects*	They are disturbed during the operation and become restless Mentally unstable subjects may suffer "psychic trauma"
12 *Patients of advanced age*	Cardiovascular changes are the rule rather than the exception If hypotension is a complication, it does not respond readily to vasopressor drugs or other therapy

b *Neosynephrine*, gr ¼ mgm intravenously very slowly
c *Desoxyephedrine*, 10 mgm Half intravenously, half intramuscularly
d *Vasoxyl*, 5 10 mgm Half intravenously, half intramuscularly
e *Oenethyl*, 50 100 mgm Half intravenously, half intramuscularly
f *Ephedrine*, gr ¾ (50 mgm), and pitressin, 5 units Half slowly intravenously, and half intramuscularly

4 *Respiratory failure* The two most common causes are these
a Central depression resulting from cerebral anemia caused by the hypotension This responds to artificial respiration and vasopressor drugs if treated immediately
b Paralysis of phrenic and intercostal nerves at the anterior roots in subarachnoid space due to cephalad migration of drug This responds to artificial respiration with oxygen by insufflation with bag and mask until nerves regain function

5 *Nausea and emesis* This complication occurs during the anesthesia There are three underlying causes
a Anemia of medulla accompanying hypotension Heralded by yawning Usually relieved by inhalation of 100% oxygen in conjunction with a vasopressor drug
b Traction on the mesentery and intra abdominal organs This causes impulses to reach the medulla via the vagi Light anesthesia with cyclopropane, pentothal, nitrous oxide, or intravenous morphine should be given
c Diffusion of the drug into the medullary area Use sedation
d Narcotics used for premedication
e Stimulation caused by vasopressors used to overcome hypotension

Contra Indications to Spinal Anesthesia	*Reasons*
1 *Cardiovascular diseases* a Myocardial disease b Hypertension, moderate or severe c Hypotension from any cause (including shock) d Disturbances of cardiac rhythm e Decompensation from any cause	Circulatory depression is a prominent and common disturbance in spinal anesthesia It is the result of physiological changes due to paralysis of central nervous system and paralysis of the sympathetic fibers The relaxation of muscles and paralysis of intercostals interfere with the venous return to the heart
2 *Neurological diseases* a Degenerative diseases of the entire or any part of the nervous system b Suppurative diseases of the nervous system	Patient may ascribe symptoms of previously existing lesions to spinal anesthesia Often of medicolegal importance

8 The patient was not placed in the correct position after injection
9 There was a delay in placing the patient in the correct position after the drug was injected

Comment	Reason
1 Never introduce a needle as far as the hub	Needles usually rust at the junction of the hub and shaft and break at this point
2 Warn the patient when the intradermal wheal is raised or the skin is cleansed	The patient may be startled and move suddenly out of the arranged position if he is not warned of such maneuvers
3 Always hold the needle with the left hand when the solution is being injected Manipulate plunger with right hand when aspirating or injecting solutions	The needle may shift if it is not held firmly Failures result from shifting of the needle
4 When attaching syringe to spinal needle to aspirate fluid or inject drug, hold it in the right hand Grasp plunger with thumb and second finger and barrel with third, fourth, and fifth, and apply to the needle	The barrel of the syringe and the plunger are both under control so that air is neither drawn in nor out and no solution is lost
5 Always use a stylet when introducing the needle Replace, after fluid is withdrawn	Tissue or blood often blocks the lumen Loss of fluid or aspiration of air into spinal canal is averted
6 If lumbar puncture is unsuccessful in one interspace, attempt it in another	"High spinal" anesthesia may be induced by injecting the drug at a lower level, and varying the technique correspondingly
7 Do not barbotage (repeatedly withdraw and reinject solution)	The level of anesthesia is difficult to control, because the drug is spread over a considerable distance in the spinal canal
8 Do not allow the patient to flex or extend his head or "strain" after drug has been injected	The drug may diffuse into the upper thoracic or cervical region from the effects of the increased venous pressure which often results from straining
9 Do not administer carbon dioxide	Carbon dioxide has no vasopressor effect

13 *Children*	Circulatory system is more labile in children The level of anesthesia is difficult to control They are psychically unsuited for surgery in a conscious state

Failures

Incomplete or unsatisfactory anesthesias are due to inexperience or to errors in technique The following are some of the more common causes of failure

1 The needle possessed too long a bevel and thus rested partly in and partly out of the subarachnoid space (Fig 113)

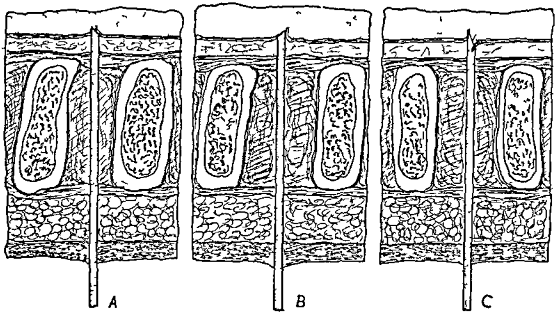

FIG 113 Effect of rotation of needle in performing lumbar puncture (A) Position of needle as it pierces the arachnoid Note the flap of tissue in lumen which interferes with free flow of spinal fluid (B) Needle rotated through an angle of 180 Note that the lumen is cleared and a free flow of fluid is insured (C) A long beveled needle used for spinal anesthesia Note that the needle is partly in and partly out of the subarachnoid space The drug will be partly if not almost entirely deposited in the extradural space

2 The needle was not held with the left hand when solution was injected and its position was shifted by the pressure on the plunger of the syringe
3 The patient moved suddenly after the puncture or during injection and caused the needle to shift its position
4 The drug was old or decomposed from heat or other factors
5 Some unknown intrinsic factor, such as resistance of the patient to the drug, tumors in the canal, or anatomical distortion, was present
6 The operator neglected to add drug to the solution
7 The solution was injected too slowly or too rapidly

20 Always have an anesthesia apparatus available for instant use, when conducting spinal anesthesia	Failure to obtain prolonged or satisfactory anesthesia may require supplemental inhalation anesthesia Respiration may fail and an inhaler may be necessary for artificial respiration
21 Record blood pressure and pulse every two or three minutes during the first 15 minutes of anesthesia, and every five minutes during the remainder of the operation	Circulatory collapse occurs most often in the period immediately after induction of anesthesia
22 Watch respiration closely Ask the patient to take a deep breath from time to time	Respiratory failure may occur before circulatory failure if the drug ascends into the cervical region
23 Never allow the patient to be unattended at any time during the course of anesthesia	Changes in the patient's status occur quickly and unexpectedly and may result in a fatality
24 Administer morphine or a barbiturate intravenously when the patient becomes restless in cases involving prolonged anesthesia (1/8 1/6 gr)	The sedative minimizes restlessness which always accompanies long anesthesia in even the most unco operative subjects
25 Remember that the level of sensory anesthesia is not an index of the degree of motor paralysis	Sensory nerves are more easily attacked by drugs and a higher level of sensory anesthesia than motor may result from diffusion
26 Always record the exact moment of injection of the drug	Reference to it may be necessary to determine whether or not it is safe to change the position of the patient during surgery
27 Cover the patient s eyes during the operation (Fig 114)	If the operating room lamps have a mirror or high polish patient may see surgery
28 Minimize conversation between members of the surgical team during the operation and bear in mind the patient is conscious	Conversation may have a disturbing psychic effect on the patient Patient may hear comments concerning the malignant disease or details of operation which may upset him

with the oxygen in the event of hypotension, nausea, or vomiting	during spinal anesthesia Increased respiratory volume may cause "pushing" during abdominal surgery
10 Administer ephedrin or other vaso pressors preoperatively only when hypotension is anticipated	Not all patients develop hypotension during spinal anesthesia Undesirable side effects may follow use of drug
11 Place the patient in the desired posi tion promptly after the drug is injected	A delay may result in diffusion of the drug to undesired levels or in failure to secure the desired level
12 Allow the patient to remain flat in bed after the anesthesia for a mini mum of four hours	The procedure is believed to avoid "spinal" headache
13 Request an attendant to hold the patient in the desired position during the induction of anesthesia	The patient may shift his position or make sudden movements during the lumbar puncture
14 Always draw back on the plunger (aspirate) when injecting any local anesthetic drug into any tissue	Avoid intravascular injection of the infiltrating agent
15 Withdraw and cleanse needle if gross blood is obtained in attempt ing the puncture Attempt puncture at another interspace	The needle may be in an artery or vein
16 Hold the needle at the hub when forcing solution in and out of the ampule (if syringe has no lock)	The needle may drop into the ampule and spoil solution by contamination
17 Strap legs and restrain wrists after anesthesia is induced	The block may fail or "wear off" during the operation and general anesthesia will be needed in which case it is de sirable to have the patient restrained
18 Be positive the spinal fluid flows freely before injecting the drug	A sluggish flow indicates needle is not properly placed in the subarachnoid space (Fig 113)
19 Always determine the level of anes thesia at frequent intervals and re cord it according to the spinal seg ment involved (Th 1, Th 2, etc)	In some techniques the height may shift during surgery

34 Color sterilizing solutions with suitable dye, such as methylene blue	Cracks in ampules may pass unnoticed if clear solution is used Dye indicates contamination has occurred

Postanesthetic Complications of Spinal Anesthesia

Headache

This is the most vexsome and annoying complication encountered in the postanesthetic period

1 *Cause* Not definitely known Believed to be due to
   a Leakage of spinal fluid from the puncture in dura Loss of cushioning effect causes traction of brain on meninges and blood vessels
   b Sterile or chemical meningismus or meningitis
   c Excess accumulation of spinal fluid

2 *Symptoms* Throbbing, pulsating headache distributed over frontal or occipital area or behind eyes or over back of the neck, aggravated by changes in posture particularly when shifting from recumbent to upright position, often accompanied by nausea, dizziness, tinnitus, etc

3 *Onset* Usually after first 24 hours after lumbar puncture, unusual immediately after puncture May be delayed seven or eight days More frequent in women than men and in apprehensive and emotional subjects

4 *Duration* Several days May be prolonged for weeks or months

5 *Contributory factors*
   a Sex More frequent in females than males
   b Type More frequent in obstetrical patients and in "low spinal"
   c Psyche More frequent in intellectual type of patients
   d Drug Of no notable significance Occurs with all drugs
   e Volume of solution used of no consequence

6 *Treatment* Therapy is directed to (a) pain relief, (b) sedation, (c) correcting or removing cause
   a Place patient at rest Changes in posture may aggravate and in certain cases cause nausea Ice cap may be beneficial
   b Administer an analgesic—aspirin, codeine, demerol, etc Start with milder analgesics and work upward, using narcotics only as a last resort
   c Sedation Phenobarbital, gr 1 0 q 4 h I M , seconal, gr 1 to 3 at night Also inhibits nausea

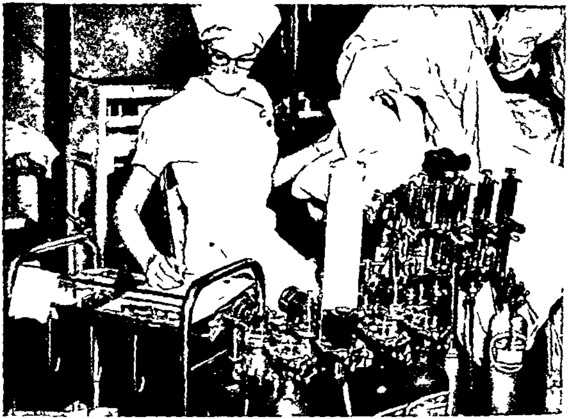

FIG 114 A towel is placed over the eyes during the surgical procedure and a trained observer watches the patient during every moment of the procedure

29	Always have a syringe and a vasopressor drug in readiness particularly at onset of anesthesia	Onset of hypotension may be rapid in many instances and treatment must be instituted without delay
30	Place the patient in the sitting position if the subject is obese or in instances of difficult lumbar puncture (Fig 125, page 369)	The vertebrae are rendered more prominent and lumbar puncture is simplified in the upright position
31	Remember that the onset of and disappearance of motor and sensory anesthesia are not simultaneous	Each type of nerve fiber responds in a different manner to a given drug
32	Use sealed, sterile, individual ampules of all drugs and solutions for intrathecal injection	Withdrawal of drugs from multiple dose vials held from without sterile field may lead to contamination or infection
33	Submerge sealed ampule in alcohol or other suitable cold sterilizing agent.	Epinephrine, ephedrine, glucose and many local anesthetics do not withstand heat sterilization

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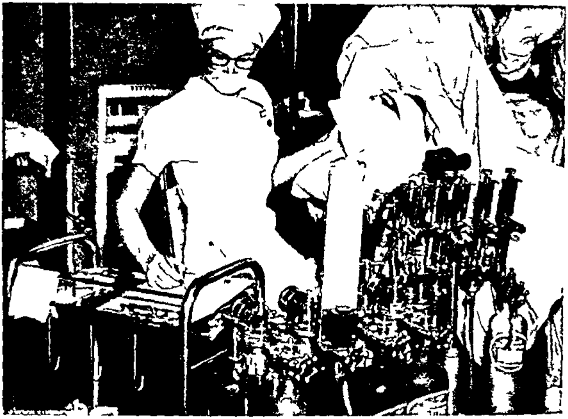

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b *Symptoms* Paralysis and loss of sensation of lower half of body Most frequently accompanied by urinary and fecal incontinence Often referred to as "cauda equina syndrome"

c *Onset* Usually heralded by excruciating pain in lower half of body accompanied by shock like state and often coma, and rapidly ensuing paralysis Also, onset may be gradual in from one to several days after the spinal anesthetic Characterized by progressive loss of sensation, paresis and loss of sphincter control

d *Probable causative factors*

(1) Pre existing neurological disease, such as cord tumors, myelitis, multiple sclerosis, combined degeneration of the cord, tabes, etc, which is aggravated by the procedure This is most probable cause Patient previously unaware of pre existing symptoms May notice them after and associate them with the spinal anesthesia

(2) *Trauma* Due to performing the lumbar puncture above L-2

(3) *Technical error* Inadvertant injection of wrong substance mistaken for the drug

(4) Idiosyncrasy or hypersensitive response to drug

(5) Use of concentrated solutions of local anesthetic drugs

(6) Contamination of drug by sclerosing agents (alcohol, phenol) used for sterilization of ampules

e *Incidence* Very infrequent Figures vary with clinics reporting 1 in 20,000 and upward

f *Treatment* Entirely symptomatic Analgesics for pain, physiotherapy, etc

g *Prognosis* This is the most serious and feared and almost entirely unavoidable complication of spinal anesthesia Unless symptoms begin to regress rapidly within several weeks the outlook is grave and damage is permanent

h *Prophylaxis*

(1) Do not use spinal anesthesia when neurological diseases are present

(2) Do not use an excess of drug or concentrated solutions

(3) Check labels carefully Do not use unlabeled ampules or ampules from which label has been lost

(4) Inspect ampules of all agents used closely for cracks and possible contamination Add a dye (methylene blue) to the sterilizing fluid if ampules are submerged for sterilization

(5) Do not perform lumbar puncture above L 2

(6) Rinse all needles and syringes with distilled water before sterilizing

d Replace spinal fluid or promote increased secretions
(1) Intrathecal normal saline until spinal fluid pressure is restored to normal, usually once or twice affords relief
(2) Intracaudal saline—30 cc , usually one injection suffices, may be repeated
(3) Peridural injection of saline—5 to 10 cc daily, if necessary
(4) Use of drugs (vasodilators or vasopressors) to promote secretion of spinal fluid Nicotinic acid, octin, pitressin, adrenal cortical extract, ergotamine, caffeine, sodium benzoate intravenously, are tried but are of questionable value
(5) Hypertonic saline 500 cc 1 5% twice daily or hypertonic glucose 50 cc 3 or 4 times daily
(6) Mechanical methods of increasing spinal fluid pressure—tight abdominal binder

7 *Prophylaxis*
a Hydrate patient preoperatively with fluids
b Keep patient at rest first 24 hours
c Use small gauge needles to perform block (25 or 26 gauge) has been suggested
d Do not suggest or mention headaches to patient
e Skillful technique in performing lumbar puncture Avoid repeated attempts at puncture
f Perform puncture with bevel of needle horizontal (suggested to avoid splitting the longitudinal fibres of the dura as little as possible) Of questionable importance

Neuropathies

A variety of neurological complications (usually unpredictable and unavoidable) may be encountered in the postanesthetic period The etiology in certain instances is unknown They are as follows

1 *Palsies* May affect any nerve, but usually affect the cranial nerves Both sensory and motor changes may be encountered The sixth nerve seems to be affected most frequently Heralded by onset of diplopia several days to a week after the lumbar puncture May last from several weeks to one year Usually involves one nerve or its branches

2 *Paraplegia* Usually confined to the legs and trunk from the waist down
a *Description* Pathological changes described are variable Myelitis, menigomyelitis, arachnoiditis, leptomeningitis, peridural abscess etc , have been found Inflammations are aseptic

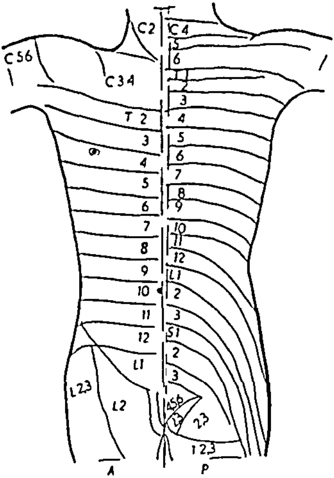

FIG 115 Sensory distribution of the body
(A) Anterior (P) Posterior

Concentration

For general use, a 5% solution This is hyperbaric, or heavier than spinal fluid A 2½% solution of procaine in distilled water is nearly isobaric

For sensory anesthesia, a 3½% solution

For intense anesthesia with marked relaxation, a 7½% solution

Materials

1 The standard spinal anesthesia set listed under *general considerations*
2 An ampule of procaine hydrochloride crystals containing the desired weight of drug
3 Ampule of epinephrine (1 mgm) 1 1 000

Procedure

1 Prepare hands and drape patient in the routine manner described under *general considerations* (page 324)
2 Perform lumbar puncture in routine manner with patient in lateral prone position as described under *general considerations*

Infections

Peridural abscess, meningitis, myelitis, etc These are usually due to infective organisms

1 *Causes*
   a Bacterial contamination of solutions, needles, catheters, gloves, drapes, or faulty aseptic technique
   b Performing lumbar puncture in presence of septicemia
   c The presence of infection about vertebral column at site of puncture
   d Coincidental presence of pre existing infection

2 *Treatment* Isolate organism and administer appropriate chemotherapeutic agent or antibiotic

Backache

1 *Causes*
   a Remaining for prolonged periods on operating table in relaxed state
   b Trauma from needle to periosteum or intraspinous ligaments
   c Trauma to intervertebral disk
   d Pre-existing orthopedic disturbance of spine or sacrum aggravated by surgery
   e Deep abscesses, hematomas, etc , due to faulty technique

Urinary Retention

Not related to spinal anesthesia May occur with any type

REFERENCES

ADRIANI JOHN Pharmacology of Anesthetic Drugs 3rd Ed Charles C Thomas Springfield Ill 1953 pp 47 51
MAXON L. H. Spinal Anesthesia Philadelphia Lippincott 1938
SCHUMACHER L. F and EVERSOLE U H The techniques of spinal anesthesia Anesthesiology 3 630-643 November 1942

SPINAL ANESTHESIA USING PROCAINE (HYPERBARIC)

Definition

Anesthesia induced using procaine as the anesthetic agent (Routine procedures described above are followed)

Dose

"Low spinal," 80 to 100 mgm , *"medium spinal,'* 120 to 150 mgm , *"high spinal,"* 150 to 200 mgm Dosage depends upon the length of the cord (number of segments) and degree of motor and sensory anesthesia desired

depending upon the drug used In order of efficiency are epinephrine, pitressin, arterenol, neosynephrine Ephedrine is ineffective The doses are as follows

TABLE XX

	Epinephrine	*Pitressin*	*Arteren I*	*Neosynephrine*
Procaine—each 50 mgm	¼ mgm	5 units	03 mgm	1 mgm
Pontocaine—each 5 mgm	¼ mgm	5 unit	03 mgm	1 mgm
Nupercaine each 2½ mgm	¼ mgm	5 units	03 mgm	1 mgm
Metycaine	¼ mgm	5 units	03 mgm	1 mgm

Spinal Anesthesia Using Pontocaine and Glucose (Hyperbaric)

Definition

Prolonged anesthesia induced by employing a solution of pontocaine made hyperbaric by glucose

Dose

"Low Spinal"—5-10 mgm (for perineal surgery)
"Medium Spinal"—12 15 mgm (for lower abdominal surgery)
"High Spinal"—15-20 mgm (for upper abdominal surgery)

Materials

1 The standard spinal anesthesia set listed under *general considerations*
2 Pontocaine hydrochloride crystals, two 10 mgm or one 20 mgm ampule A 0 5% solution, crystals or microcrystals may be used
3 Glucose (5% aqueous solution) 5 cc
4 Shoulder braces for the operating table
5 Epinephrine 1 1000—(1 cc) ampule

Procedure

1 Record preanesthetic pulse and blood pressure and arrange patient in the lateral prone position as described under *general considerations*
2 Dissolve pontocaine in 4 cc glucose Mix well by drawing pontocaine solution in and out of the ampule with the syringe If solution is used mix equal portions with the glucose solution Draw up the desired amount (1 cc = 5 mgm of drug) into the syringe Add ¼ mgm epinephrine (¼ cc) for each 5 mgm pontocaine
3 Perform lumbar puncture in routine manner at desired level—L2 or 3 for "high spinal," L3 or 4 for "low spinal "
4 Inject solution at rate of 1 cc per second for "high spinal," or at rate of 0 5 cc per second for "low spinal "
5 Note and later record exact moment of injection of drug
6 Immediately turn patient to the supine position and arrange as follows

3 Apply syringe to the spinal needle and withdraw 2 cc of spinal fluid for each 100 mgm of procaine to be used (for 5% solution) Remove syringe and reinsert stylet Or

3a Dissolve the drug in physiologic saline and have in readiness for injection as soon as puncture is complete

4 Apply Wassermann needle to syringe and force spinal fluid in and out of ampule containing procaine crystals until they are dissolved Add ½ cc of epinephrine (0 5 mgm)

5 Remove the stylet from needle, attach and lock syringe containing procaine solution to the hub with right hand Hold needle with left hand

6 Aspirate approximately 0 1 cc of spinal fluid to ascertain needle is still properly placed If a free flow is not obtained, readjust the needle

7 Inject solution taking precautions mentioned under general directions Use rate of 1 0 cc per second for "high" spinal, 0 50 cc per second for "low" spinal When injection is complete, aspirate 0 1 cc and reinject (to assure that needle has not been dislodged during manipulations)

8 Withdraw needle and turn patient to supine position Operating table should be level Support head on pillow

Anesthesia

1 *Onset* Anesthesia is completely established within three minutes

2 *Duration* It usually averages one hour but ranges from three quarters of an hour to one and one half hours With epinephrine it may last two hours

Comment

1 Remember that the level of anesthesia with procaine is attained by varying the rate of injection (diffusion) rather than by gravitation

2 Use the upper limit of dose range and a rapid rate of injection to force drug high into canal in tall subjects

3 Allow five minutes after injection before shifting to Trendelenburg position if this position is required

4 Use a 3½% solution for diffuse sensory anesthesia without undue motor paralysis

5 Employ a 7½% or 10% solution if marked relaxation is desired

6 Employ the lower dosage range in debilitated or old subjects

PROLONGATION OF ANESTHESIA WITH VASOCONSTRICTORS

Vasoconstrictor substances combined with the spinal anesthetic agent prolonged duration of anesthesia and intensify motor effects from 50 75%,

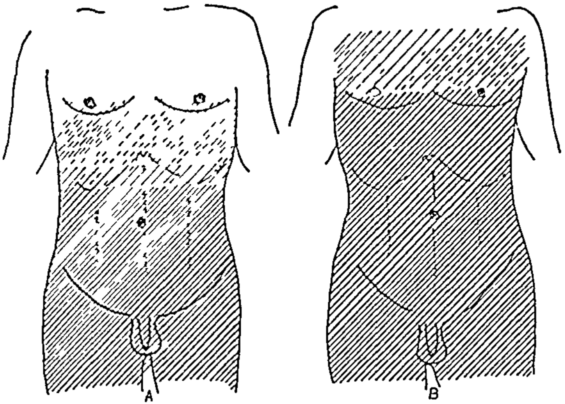

FIGURE 116 The ascent or "creeping" effect of long acting spinal anesthetic drugs Solid lines indicate anesthesia dotted lines hypalgesia (A) During induction (B) After anesthesia is fully established Note that hypalgesic areas in (A) have become anesthetic in (B) and that upper thoracic segments have become hypalgesic To prevent creeping following ascent of drug in spinal canal by studying the hypalgesic zones rather than the anesthetic

FIGURE 117 The head is sharply flexed and supported by a pillow immediately after injection of a hyperbaric solution to prevent cephalic migration of the drug

a For a "high spinal" tilt table to a 10° Trendelenburg position for one to three or four minutes and follow the ascent of hypalgesia (not anesthesia) closely from moment to moment When *hypalgesia* is established at the desired level, place the patient in the flat position (Fig 110) This may require less than one minute but may take up to three or four minutes
b For "medium spinal" tilt the table to a 5° Trendelenburg position and allow the patient to remain in this position until desired level of hypalgesia is established Then place in level position (Fig 110)
c For "low spinal," place in level position until hypalgesia extends to the desired level Then place in 5° Fowler's position (Fig 110)

Anesthesia

1 *Onset* Requires 5-10 minutes to become fully established
2 *Duration* Averages two hours but it may last from 1½ to four hours Epinephrine increases duration 60 to 80%

Comment	*Reason*
1 Test level of anesthesia frequently during the first five minutes If it extends beyond the desired height, place the patient in 5° Fowler s position (Fig 143)	The pontocaine solution is hyperbaric and gravitates cauded Reversal of position causes drug to regress
2 Flex the head sharply by supporting on thyroid rest or on a doubled pillow (Fig 152)	This prevents the drug from ascending into the cervical region even though it reaches the upper thoracic segments
3 Administer morphine and scopolamine or a barbiturate intravenously if the patient becomes restless during the anesthesia (gr 1/8 1/6)	Prolonged surgery is tiring to patient and may cause discomfort even if anesthesia is satisfactory
4 Induce anesthesia with patient lying on pathological side in nephrectomy or other types of surgery performed with patient on his side	More intense anesthesia is obtained on that side because drug is hyperbaric and is deposited there
5 Wait 10 minutes if Trendelenburg position is required Otherwise, place patient in 10° Fowler s position for two minutes, then in desired inclination	If the table is allowed to remain tilted, the drug diffuses cephalad
6 Remember that the motor paralysis usually requires a longer interval to appear after injection than the sensory	Motor fibers are the last to be affected by local anesthetic drugs

Procedure

1 Record preanesthetic blood pressure and pulse rate and arrange patient in a lateral prone position Do not support head on a pillow
2 Warm anesthetic solution to body temperature by placing the ampule in tepid water (50° C)
3 Warm 20 cc syringe by forcing tepid sterile physiological saline through it Fill with desired volume of anesthetic solution
4 Perform lumbar puncture in the usual manner using a 20 gauge needle Remove 5 cc of spinal fluid with the 5 cc syringe and discard it
5 Attach the syringe containing the drug and inject the drug at a rate of ½ cc per second *The rate should be constant from start to finish and not interrupted or changed*
6 Turn patient immediately to the prone position (use shoulder braces) as soon as the injection is complete
7 Immediately tilt table to a Trendelenburg position of 10°-15°
8 Elevate the thyroid bar or place a pillow under the thorax so that the head is well flexed but thoracic portion of vertebral column is level or nearly level depending upon level of anesthesia desired (Fig 111)
9 "Break" table and also tilt feet at same angle as head if shoulder braces are not available (Fig 111)
10 Test the level of anesthesia with a sharp instrument every half minute during the first 10 minutes At end of 10 minutes, straighten feet and place the patient in the supine position, but allow to remain in Trendelenburg position for an additional five minutes

Anesthesia

1 *Onset* It requires 10 to 15 minutes
2 *Duration* It lasts from two and one half to five hours, with an average duration of three hours Epinephrine prolongs it 60 75%

Comment	*Reason*
1 Maintain the head lower than the remainder of the body at all times during the establishment of anesthesia	The solution is hypobaric and does not diffuse cephalad in this position
2 Do not shift the patient into the supine position until at least 10 minutes have elapsed after injection of the drug	Anesthesia is not established immediately when nupercaine is used Longer lasting drugs require a longer time to be fixed
3 Inject the solution at a constant rate,	"Patchy" anesthesia may result The

7 Do not exceed 20 mgm at any single injection	Pontocaine is a highly toxic drug which could cause irreversible changes if used freely
8 Test the level of *hypalgesia* and anesthesia from moment to moment throughout the early part of operation	The anesthesia tends to "creep" beyond the initially established level Hypalgesia precedes analgesia It appears immediately (Fig 116)
9 Remember that complete anesthesia requires from 10 to 15 minutes to be fully established	The onset of action is delayed when longer acting anesthetic drugs are employed Anesthesia follows hypalgesia

REFERENCE

Sise L F Pontocaine glucose solution for spinal anesthesia S Clin North America, *15* 1501 1511 December, 1935, *16* 1707 1711, December, 1936

Spinal Anesthesia Using Procaine and Glucose (Hyperbaric)

Use procaine hydrochloride crystals in doses described under *Spinal Anesthesia Using Procaine* (p 348) Mix with glucose 5% in saline or distilled water using 1 cc for each 50 mgm of procaine hydrochloride Follow the technique described above for pontocaine with glucose Epinephrine ¼ mgm per 50 mgm procaine may be added to prolong anesthesia

Spinal Anesthesia Using Nupercaine (Hypobaric)

Definition

Prolonged anesthesia produced by employing a solution of nupercaine and dilute sodium chloride

Materials

1 One standard spinal anesthesia set listed under *general considerations*
2 One ampule (20 cc) of a solution of nupercaine hydrochloride containing 1 mgm in 1½ cc of ½% saline (1/1500), known as Jones' solution (warm to 37° C)
3 One syringe (20 cc) with Luer lock
4 Shoulder braces to support patient
5 Pillow or thyroid rest
6 One ampule 1 1000 epinephrine (1 cc)

Dose

"Low spinal," 8-12 cc of 1 1500 solution
"Medium spinal," 12-15 cc of 1 1500 solution
"High spinal," 15-18 cc of 1/1500 solution
Add ¼ mgm epinephrine for each 5 mgm nupercaine used

or evipal 1% by intravenous drip slowly, seconal 100 200 mgm I V, pentobarbital 100 200 mgm I V, morphine gr 1/6 to 1/4 combined with scopolamine 1/200 1/100 I V

For nausea Allow patient to inhale oxygen If nausea persists, induce surgical anesthesia with cyclopropane, pentothal nitrous oxide, or seconal, as above

"One Legged" Spinal Anesthesia (Hyperbaric Technique)

Definition

Anesthesia for one leg induced by subarachnoid block, using a hyperbaric solution

Uses

For operations on one extremity Usually selected for "poor risk" patients

Materials

1 Drug of choice—determined by duration desired (see below)
2 10% glucose 1 cc
3 Standard spinal set as in other forms of spinal anesthesia
4 Operating table which can be tilted

Dose of Drug

Procaine 75 mgm —dissolve in 1 cc glucose 10%
Pontocaine 5 mgm —dissolve in 1 cc glucose 10%
Nupercaine 3½ mgm —mix with 1 cc glucose 10%
Epinephrine ¼ mgm added to any of above if prolonged anesthesia is desired

Procedure

1 Prepare solution Check needle, syringe, etc, as for any spinal anesthetic technique
2 Place patient in lateral recumbent position with diseased extremity *down*
3 Incline table 20° head up, feet down
4 Perform lumbar puncture in usual manner
5 Inject solution as fast as gentle pressure on plunger permits
6 Allow patient to remain on side for 10 minutes, after which time he is placed in the dorsal recumbent position

Precautions

1 Watch blood pressure, pulse and respiration in same manner as for other techniques of spinal anesthesia
2 Allow patient to remain in tilted position for an additional five minutes

neither too rapidly nor too slowly Use a watch to gauge the rate of injection	level may be too low or too high
4 Do not exceed 20 cc (15 mgm of drug) of solution at any time	Nupercaine is highly toxic and may injure tissues if excessive amounts are employed
5 Use clean glassware at all times Slightly acidify syringe before sterilization	Nupercaine precipitates in alkaline solutions which have a pH as low as 7 1
6 Do not use a needle of small bore in performing lumbar puncture	A small bore interferes with the desired rate of injection
7 Allow the patient to remain in prone position until level recedes if anesthesia should extend too far cephalad	The drug diffuses upward and involves sensory roots to a greater extent than motor roots in the prone position The intercostal muscles remain active
8 Use lower limits of dosages for short subjects and upper limits for tall individuals	More drug is required, when the cord is longer, to obtain satisfactory anesthesia

REFERENCE

JONES W H Spinal analgesia a new method and a new drug Percaine *Brit J Anes*, 7 99 113 April 1930

NUPERCAINE GLUCOSE (HYPERBARIC) TECHNIQUE

Follow exactly the same technique described for pontocaine glucose (page 351) using the following doses of a 1 200 buffered solution

"High spinal," 10 15 mgm
"Medium spinal," 7-10 mgm
"Low spinal," 5-7 mgm

COMMENT

1 Nupercaine not available in crystalline form
2 For each 5 mgm (1 cc) use 1 cc 10% glucose

SUPPLEMENTING SPINAL ANESTHESIA

For incomplete block Use an inhalation anesthetic—cyclopropane, ethylene ether, nitrous oxide ether, nitrous oxide pentothal, evipal or surital, barbiturate with curare, if indicated

For block which has failed Same as above

When operation outlasts block Same as above

For a satisfactory block, but the patient is apprehensive Pentothal, surital

This should possess hard wall 3 *mm diameter* (It must not bulge and fill up with an excess of solution (Fig 119))

5 One Wassermann needle (19 gauge or 20 gauge)
6 One hypodermic syringe and needle for wheals
7 1% procaine solution for wheal
8 One medicine glass (2 oz)
9 One flexible German silver needle (18 gauge) and one flexible German silver needle (20 gauge) [illegible] to 4 long (Fig 119)
10 One introducer (a 15 gauge needle filed in half longitudinally and cut to a two inch length may be used) (Fig 119)
11 Several ampules of 200 mgm procaine hydrochloride crystals
12 Physiological saline for preparation of solutions
13 Skin sterilizer, towels, clamp etc
14 Several ampules of ephedrine sulphate, $\frac{3}{4}$ gr (48 mgm)
15 One holder or rest for the syringe
16 Shoulder braces and wrist cuffs

Premedication

Patients become restless during long operations performed with spinal anesthesia Therefore, sedation should be good *Administer* Morphine, gr $\frac{1}{6}$ to $\frac{1}{4}$, with scopolamine, gr $\frac{1}{150}$ to $\frac{1}{100}$, one hour preoperatively, by hypodermic needle Barbiturate—seconal, nembutal, or similar short acting barbiturate in therapeutic doses, one hour before anesthesia Ephedrine, intramuscularly, before anesthesia is induced (48 mgm), if hypotension is anticipated Repeat morphine during operation if surgery is prolonged Intravenous short acting and ultra short acting barbiturates may be used

Dose

1 This varies with the age, sex, and height of the individual, and type of operation Initial dose for average sized adult should be approximately 150 mgm
2 Repeat doses vary between 80 to 100 mgm when anesthesia recedes

Contra Indications

Same as for spinal anesthesia by other methods

Technique

1 Dissolve the procaine in physiological saline to form approximately a 3% solution (100 mgm in 3 cc saline)
2 Fill the 10 cc syringe with this solution Attach stopcock to the syringe and tube to stopcock Open stopcock and fill tube with solution When all air is forced out and tube is filled close stopcock (This requires approximately 2 cc of fluid)

Continuous Spinal Anesthesia

Definition

Anesthesia inducted by the ordinary technique but modified so that the spinal needle (or a flexible catheter) remains *in situ* This is accomplished by the aid of an elevated special mattress provided with a recess for the

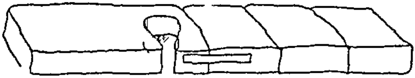

Fig 118 Special mattress for continuous spinal anesthesia Note the segmental arrangement which allows use of lithotomy and positions other than level on the table

needle Successive repeated doses of the drug are added from a syringe through a tube connected to the needle during the course of the operation

Synonyms

Repeated spinal, serial spinal or fractional spinal

Uses

For operations expected to last over one hour

Materials

1 One special mattress 18″ × 6′ × 6″, with a recess approximately 8″ × 10″ in the region over which the lumbar vertebrae would lie when patient is in supine position (Fig 118)
3 One two way stopcock to fit the syringe and tube (Fig 119)
4 One three foot rubber tube with the adapter for syringe and needle

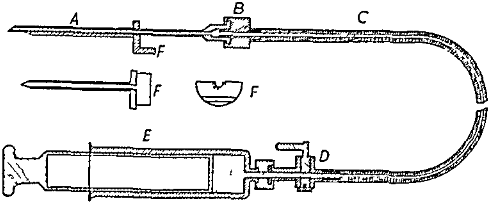

Fig 119 Assembly of continuous spinal anesthesia (A) Soft malleable silver needle (B) Lock (C) Thick walled rubber tubing (D) Two way stopcock (E) 10 cc syringe (F) Top, side and end views of the introducer

6 Administer morphine, gr 1/6 to 1/4, and scopolamine, gr 1/150 to 1/200, intravenously if the patient becomes restless or complains of discomfort
7 The successive doses required as the operation progresses are smaller than the initial dose
8 Anticipate the point at which the anesthesia "wears off" and inject the next dose before it "wears off"
9 No definite limit is placed upon the number of successive doses which one can employ
10 Do not allow the introducer to remain *in situ* under any circumstances

REFERENCES

LEMMON W T * A method for continuous spinal anesthesia Ann Surg *111* 141 145, January 1940

CONTINUOUS SPINAL ANESTHESIA—CATHETER TECHNIQUE

Materials

1 Plastic catheter #4—30 to 60″ long with centimeter markings on the first 12 cms (Fig 121)
2 Tuohy needle with stylet (Fig 121)
3 Wheal needle and syringe
4 Rubber adapter to fit over free end of catheter (or the top of a 22 gauge needle)
5 Syringe to connect to adapter or needle top
6 Adhesive

Procedure

1 Raise an intradermal wheal at the desired interspace and infiltrate the deep tissues
2 Introduce 19 gauge needle into the subarachnoid space
3 Slip larger needle over 19 gauge needle and introduce it until the ligamentum flavum is encountered Avoid introducing it into the sub arachnoid space (Fig 121)
4 Withdraw 19 gauge needle entirely Maintain grasp on larger needle during this maneuver
5 Introduce the catheter through the needle and pass into the sub arachnoid space for a distance of 4 cms beyond end of the needle
6 Remove the large needle without disturbing the catheter in place Secure with adhesive over site of puncture
7 Attach adapter and syringe to catheter and introduce drug in same manner as described above

* Originated the technique

3 Place patient on side in usual position for lumbar puncture (the patient's back should face the opening in side of mattress)
4 Raise an intradermal wheal over interspace of L2 or L3 and anesthetize interspinous space with 1% procaine
5 Insert the introducer into the interspinous space and prepare a tract for the needle
6 Insert the malleable spinal needle through the path prepared by the introducer and perform the puncture as in other techniques
7 Attach distal end of tube to spinal needle
8 Turn patient on his back (flat) so that needle is in recess in mattress and touches nothing Patient should make no effort to assist in turning Assistants should turn patient
9 Tilt table to 5° to 10° Trendelenburg position after shoulder braces are applied
10 Open the stopcock and aspirate 1½ cc of spinal fluid into tube Reinject 3 cc (1½ cc of spinal fluid and 3 cc of solution) Withdraw 1½ cc more and reinject 3 cc (barbotage) Withdraw 1½ cc more and reinject 3 cc, giving a total of 150 mgm of procaine
11 Close the stopcock and fasten syringe securely with adhesive at the head of table on a rest
12 At the end of 45 to 50 minutes, repeat the injection, using 80 100 mgms Inject by the barbotage technique

Advantages

It allows the use of repeated doses of drugs of relatively low toxicity (such as procaine)

Disadvantages

1 The needle may shift and technique may fail
2 There is a possibility of central nervous system changes from repeated or prolonged use of the drug
3 The mattress interferes with the convenience of the surgical team
4 Considerable time is often consumed in executing the technique

COMMENT

1 Watch the patient closely after each injection Observe the level of anesthesia as well as circulation and respiration
2 Remember that the onset of anesthesia is often delayed, sometimes as long as five minutes after the injection
3 Control the hypotension which often follows each injection with intravenous ephedrine as in the "one dose" technique
4 Use only soft silver needle for performing the puncture and always use an introducer
5 Inspect all connections for leaks

COMMENT

1 Do not use old, worn or cracked catheters
2 Sterilize catheters by immersing in bichloride of mercury

REFERENCE

Tuohy, E B Continuous spinal anesthesia Its usefulness and technique involved Anesthesiology 5 142 148 March 1944

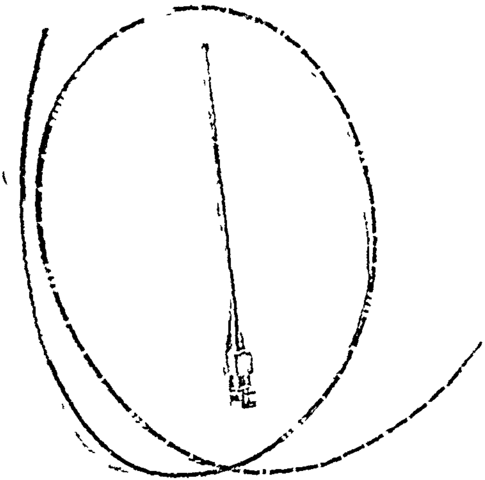

FIGURE 121 Catheter for use for continuous spinal anesthesia together with Tuohy needle Plastic catheters may be used in place of the fine gauge ureteral catheter shown The needle has a special point or tip known as the Huber point

SEGMENTAL CONTINUOUS SPINAL ANESTHESIA

Description

Continuous spinal anesthesia induced by introducing and threading the cephalad or caudad catheter in the subarachnoid space and localizing the block to several desired spinal segments

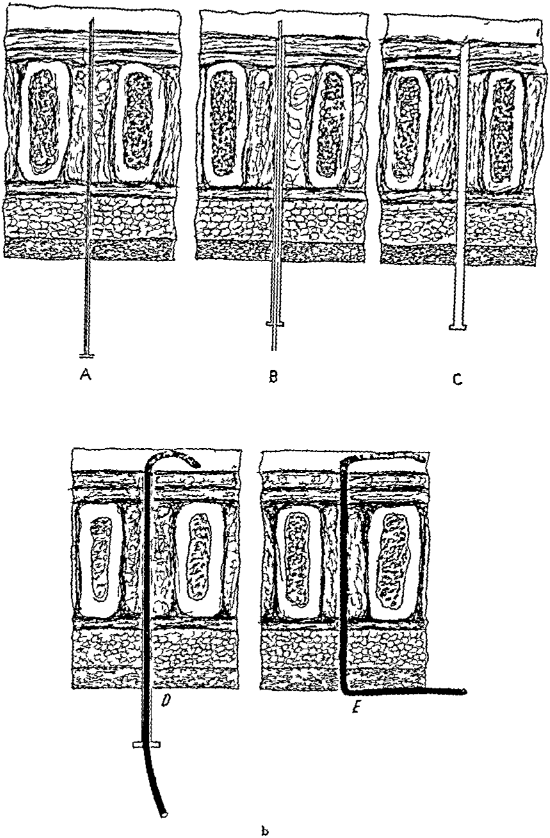

Fig 170 Assembly for continuous spinal anesthesia by catheter technique (A) Special spinal needle (without flange) and stylet placed in the subarachnoid space (B) Outer trochar introduced as far as the dura stylet of inner needle out (C) Inner needle removed (D) Catheter introduced into subarachnoid space to replace inner trochar (E) Outer trochar removed and the catheter properly placed

COMMENT

1 Do not use old, worn or cracked catheters
2 Sterilize catheters by immersing in bichloride of mercury

REFERENCE

TUOHY E B Continuous spinal anesthesia Its usefulness and technique involved. Anesthesiology 5 142 148 March 1944

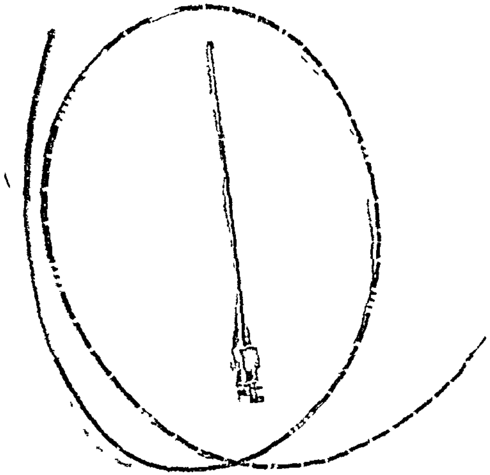

FIGURE 171 Catheter for use for continuous spinal anesthesia together with Tuohy needle Plastic catheters may be used in place of the fine gauge ureteral catheter shown The needle has a special point or tip known as the Huber point

SEGMENTAL CONTINUOUS SPINAL ANESTHESIA

Description

Continuous spinal anesthesia induced by introducing and threading the cephalad or caudad catheter in the subarachnoid space and localizing the block to several desired spinal segments

Material

1 Continuous spinal set
2 Tuohy 16 gauge needle with Huber point
3 Plastic catheter which is marked in centimeters

Procedure

1 Introduce spinal needle at L3 or L4 with bevel pointing laterally Patient in lateral position
2 Withdraw stylet and rotate needle to point cephalad or caudad, as desired
3 Inject 5 mgm pontocaine dissolved in 1 cc 5% dextrose
4 Introduce catheter and advance 15 to 35 cms in the subarachnoid space beyond the point of needle depending upon distribution of anesthesia desired
5 Withdraw needle as the catheter is introduced
6 Attach needle to catheter and connect with stopcock and syringe
7 Attempt aspiration of spinal fluid to ascertain if catheter is properly placed
8 Wrap sterile piece of gauze 3 cm or 4 cm square around point of emergence of catheter to prevent contamination
9 Turn patient in prone position and support head on pillow

COMMENT

1 The catheter is inserted cephalad to one or two dermatomes below the desired level of anesthesia
2 Never withdraw the catheter over the needle It may become sheared or shaven
3 Measure the desired distance from point of lumbar puncture to desired dermatomes before proceeding
4 Inject 2-3 mgm of solution at hourly intervals The amount and frequency are determined by the height of anesthesia and reactions of patient
5 For patients on side (kidney operations, etc) or for injections in sacral area hypobaric solution of 1 1000 pontocaine may be used Use "head down" position
6 Procaine with glucose may be substituted for pontocaine Dosage on milligram basis is 10 times as much

REFERENCE

SAKLAD M DWYER C et al Anesthesiology *8* 270-287 May 1947

Continuous Drip Continuous Spinal Anesthesia (Arrowwood and Foldes)

Description

Continuous spinal anesthesia induced by the techniques described above and maintained by connecting the indwelling catheter to a reservoir of procaine solution and allowing the solution to drip in continuously

Materials

1 Continuous spinal set described above
2 Leveling bulb for solution 250 cc capacity
3 Procaine 0 5%
4 Two way stopcock
5 Murphy drip
6 Stand for drip
7 Needle valve to regulate flow
8 Stop watch

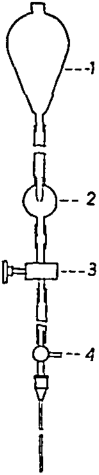

Fig 123 Assembly for continuous drip" of continuous spinal anesthesia (1) Leveling bulb (2) Drip (3) Needle valve for controlling the rate of flow (4) Two-way stopcock. The stopcock fits into the needle or the adaptor to the continuous spinal catheter

Procedure

1 Induce anesthesia injecting 6 cc 2 5% procaine in 2 5% glucose in isotonic sodium chloride (150 mgm procaine) (Fig 122)
2 Place table in 5% Trendelenburg and establish anesthesia to desired level
3 Suspend leveling flask containing 5% procaine 60 80 cms above level of spinal needle
4 Withdraw the procaine in the catheter in the connecting tube and other attachments (The volume should be determined for a particular set-up before anesthesia is induced)
5 Attach stopcock tube and tube from leveling bulb set up to the catheter
6 Immediately replace fluid in catheter with 0 5% procaine from set-up
7 Regulate valve to deliver the desired amount of procaine (usually eight drops per minute for upper abdominal surgery (on basis of 20 drops = 1 cc)

Comment

1 Determine the volume of solution which will be contained in the needle, catheter and adapters and mark it on the set up
2 Calibrate the dropper in cubic centimeters per minute so that number

of drops per cubic centimeter will be known for that particular dropper

3 Test cutaneous levels of anesthesia at frequent intervals in order to be assured that level has not receded
4 Check the rate of flow dropping of procaine It varies with the spinal fluid pressure

Differential Spinal Block (Arrowwood and Sarnoff)

Description

A subarachnoid block induced with dilute procaine solutions to obtain block of sudomotor, vasomotor, pin prick sensation while maintaining motor power, position, vibratory, touch and deep pressure sensations

Uses

For diagnostic and therapeutic purposes in which autonomic blockade is desired without loss of motor power

Materials

1 Same as for continuous drop spinal technique, described in preceding section
2 2% procaine solution

Procedure

1 Perform puncture at L3 or L4
2 Introduce 15 to 18 cc of 0 2% procaine solution
3 Continue at rate of 0 6 cc per minute as long as block is needed

REFERENCES

Sarnoff, S J and Arrowwood J G J Neurophysiol 10 205 209 1947
Arrowwood J G and Foldes F Arch Surg 49 241 244 1944

Intraspinal Alcohol

Description

Production of anesthesia, usually permanent, of certain segments by the intrathecal injection of alcohol Anesthesia is confined to the sensory fibers by using small volumes of alcohol

Uses

For the relief of intractable pain in malignant disease when all other forms of therapy have failed

Materials

1 Absolute alcohol sterilized to insure no contamination by spores
2 Tuberculin syringe
3 Standard spinal set

Procedure

1 Place patient in lateral prone position with afflicted side uppermost

2 Perform lumbar puncture at site of spinal segments in which pain relief is sought
3 Withdraw 2 or 3 cc spinal fluid into a small syringe and discard
4 Inject 0 5 cc absolute alcohol into the subarachnoid space Alcohol must be accurately measured and injected slowly (about 60 seconds)
5 Turn patient into the prone position and allow to remain at an angle of 5° Trendelenburg for approximately 30 minutes

COMMENT

1 Alcohol is hypobaric and gravitates upward
2 The stated quantity of alcohol is sufficient for only one or two spinal segments Repeat injection in other areas if anesthesia does not cover desired area
3 Motor paralysis may result if stated quantity of alcohol is exceeded
4 Premedication, technique, preparations and precautions are same as for spinal anesthesia

SADDLE AND MODIFIED SADDLE BLOCK ANESTHESIA

Definition

A form of low spinal anesthesia confined exclusively to the perineal area (distribution of sacral nerves) By varying the technique the following distributions of anesthesia may be obtained (Fig 124)

1 Perineal analgesia and relaxation of pelvic muscles and sphincter—no analgesia or paralysis of the extremities (true saddle) (Figs 123, 124)
2 Perineal analgesia and relaxation of pelvic floor with analgesia but no motor paralysis of the extremities (modified saddle) (Figs 126 127)

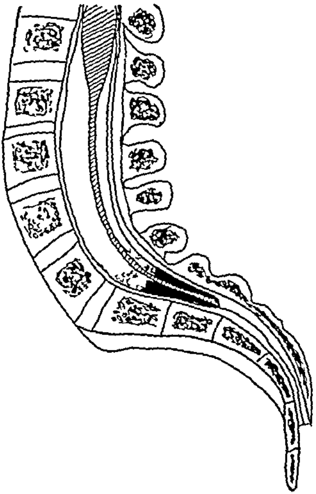

FIG 123 Cross section of lower portion of spinal canal showing dural sac ending at S 2 When a hyperbaric solution is injected with the patient in the upright sitting position the drug becomes localized in the conus after one minute and the sacral roots alone are affected A true saddle block results.

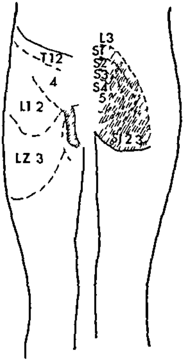

FIG 174 Distribution of anesthesia in a true saddle block Only the perineal areas are anesthetized

3 Sensory anesthesia and motor paralysis of the legs and perineum No abdominal involvement (low spinal)

Uses

1 *Saddle* Rectal, urological, gynecological surgery involving perineum, rectum, scrotum, but not pelvic organs such as bladder fundus of uterus, etc
2 *Modified saddle* Rectal, urological, gynecological surgery requiring lithotomy position
3 *Low spinal* Orthopedic, rectal, urological, and perineal surgery requiring loss of pain sensation in the fundus of the uterus, dome of the bladder and other pelvic structures

Drug

Procaine, metycaine, or monocaine for short procedures, pontocaine or nupercaine for long procedures Dosage and concentration and duration of action are summarized in the following table

TABLE XVI

VARIATIONS IN DOSAGE VOLUME OF SOLUTION AND TIMING NECESSARY TO OBTAIN SADDLE OR LOW SPINAL ANESTHESIA WITH THE CURRENTLY EMPLOYED ANESTHETIC DRUGS

Drug	Preparation	Anesthesia in Saddle Area				Saddle Anesthesia Sensory of Extremities				Low Spinal Motor and Sensory of Extremities			
		Dose (mg)	*Time Patient Sits Upright (sec)*	*Duration of Anes (hr)*	*Glucose Solution (cc)*	*Dose (mg)*	*Time Patient Sits Upright (sec)*	*Duration of Anes (h)*	*Glucose Solution (cc)*	*Dose (mg)*	*Time Patient Remains Upright (sec)*	*Duration of Anes (hr)*	*Glucose Solution (cc)*
Procaine	Crystals	50-75	35-40	1¼-1½	1	75-100	15-20	1¼-1½	1 5	100-125	0-5	¾-1	2 0
Metycaine	10% solution	50-75	35-40	1½-1¾	1	50- 75	15-20	1½-1½	1 5	75-100	0 5	1 -1½	2 0
Intracaine	Crystals	20-25	35-40	1¼-1½	1	25- 30	15-20	1¼-1½	1 5	30- 35	0-5	1 -1½	2 0
Monocaine	Crystals	35 50	35-40	1½ 2	1	20- 75	20	1½-1¾	1 5	75	0-5	1½-1¾	2 0
Pontocaine	Crystals or powder	5	35-40	2 -2½	1	5 8	20	2 -2½	1 5	8- 10	0 5	2 -2½	2 0
Nupercaine	0 5% solution	2½	40	3½-4	1	2½ 5	20	3½ 4	1 5	5	0-5	3 -3½	2 0

Materials

1 Standard set for spinal anesthesia
2 Drug desired for the contemplated procedure
3 Glucose (10% in physiological saline or distilled water)

Procedure

1 Dissolve or mix the drug (depending upon the preparation selected) with the necessary amount of glucose, draw into syringe and set aside until lumbar puncture is performed

Fig 125 Position in performing saddle block The upright sitting position is mandatory for performing a saddle block

2 Place patient in upright sitting position with legs dangling over side of the table, shoulders supported by an assistant The patient should lean forward slightly (Fig 125)

3 Perform lumbar puncture at L_4 L_3 may be used if L_4 is not accessible

4 Attach syringe containing drug to needle, inject solution as rapidly as gentle pressure on the plunger permits

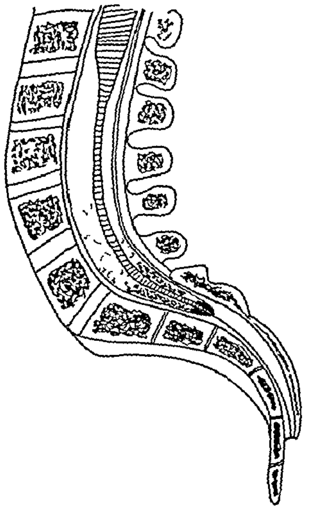

FIG 176 Cross section of lower portion of spinal canal showing the dural sac ending at L 2 The time the patient sits upright is shortened to thirty seconds or less The drug diffuses into the lumbar segments and a block of varying intensity or modified saddle block results

5 Withdraw needle Allow patient to remain upright the necessary time (see table) Use a watch for timing
6 Restore to the recumbent position Place a pillow doubled upon itself under the head
7 Place the table in Fowler s position at an angle of 5° for 5-10 minutes

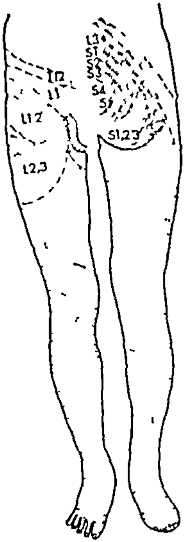

FIG 127 Distribution of anesthesia in a modified saddle block The shaded area represents true anesthesia Hypalgesia and paresis are present in the dotted areas

COMMENT

1 Timing and volumes of solution must be accurate
2 Inject drug as rapidly as gentle pressure upon the syringe allows

3 Identify the area affected by the zone of hypalgesia which immediately ensues Anesthesia requires approximately five minutes to be completely established
4 Do not change to lithotomy, Sims, Trendelenburg or other position for 10 minutes after the injection

SADDLE BLOCK FOR OBSTETRICS USING NUPERCAINE

The technique is followed exactly as above with the following modifications

1 Use 2½ mgms nupercaine (or 5 mgm pontocaine)
2 Use 1 cc 10% glucose solution
3 Allow patient to remain upright *30 seconds*
4 Do not perform injection during a uterine contraction The drug will be forced upward

REFERENCES

ADRIANI J and ROMAN D A Saddle block anesthesia. Am. J Surg 71 12 18 January 1946
PARMLEY R. T and ADRIANI, J Saddle block anesthesia in obstetrics using nupercaine South Med J 39 191 195, March 1946

SADDLE BLOCK ANESTHESIA (HYPOBARIC TECHNIQUE)

Definition

Saddle block anesthesia induced by using a hypobaric solution of a local anesthetic intrathecally and confining it to the sacral segments

Indications

For operations and diagnostic procedures requiring anesthesia of the saddle area in which the prone position is mandatory

Materials

1 Standard spinal anesthetic set
2 Potent drug (pontocaine or nupercaine) which will yield a hypobaric solution in a small volume of distilled water
3 Sterile distilled water

Technique

1 *Position*

a Place the patient in the prone position with the hips level with the "break" of the operating table
b Place two pillows to support the lower part of the abdomen This eliminates the lumbar curve

c Incline the lower half of the table to an angle of 45 to 50° in order to separate spines of vertebrae
d Lower the head of the table slightly to approximately 10°

2 *Procedure*

a Prepare the skin
b Raise a skin wheal and perform the interspinous injection with procaine at the 3rd and 4th lumbar interspace Lateral route may be used
c Perform lumbar puncture Aspirate if spinal fluid does not flow freely
d Turn the bevel of the needle caudad As soon as spinal fluid is obtained lower the operating table to a 30° position
e Inject solution (5 cc of 010% pontocaine or 4 cc of 0 75% nupercaine 1 1500) in a period of two to five seconds Allow patient to remain in prone position with head down
f Withdraw needle and remove pillows beneath the abdomen

Anesthesia

1 *Onset* Five to 10 minutes
2 *Duration* Pontocaine 1½ to two hours, Nupercaine two to 2½ hours
3 *Distribution* Complete in saddle area Hypalgesia and possibly paresis may be present in the extremities

Complications

Drug may spread to higher spinal segments and produce a greater extent of anesthesia than saddle distribution

COMMENT

Lumbar puncture is not always feasible in prone position In event of failure use lateral prone position with head down position of 15 20° Place in the prone position, table tilted immediately after injection

EPIDURAL ANESTHESIA

Definition Anesthesia obtained by blocking the spinal nerves as they pass through the epidural space

Synonym Peridural anesthesia, extradural anesthesia

Types Two types are available according to the route used *to obtain access* to the epidural space

1 "Spinal" epidural or lumbar epidural *This is obtained by introducing a needle between the lumbar spines as for lumbar puncture*

3 Identify the area affected by the zone of hypalgesia which immediately ensues Anesthesia requires approximately five minutes to be completely established
4 Do not change to lithotomy, Sims, Trendelenburg or other position for 10 minutes after the injection

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The technique is followed exactly as above with the following modifications

1 Use 2½ mgms nupercaine (or 5 mgm pontocaine)
2 Use 1 cc 10% glucose solution
3 Allow patient to remain upright *30 seconds*
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SADDLE BLOCK ANESTHESIA (HYPOBARIC TECHNIQUE)

Definition

Saddle block anesthesia induced by using a hypobaric solution of a local anesthetic intrathecally and confining it to the sacral segments

Indications

For operations and diagnostic procedures requiring anesthesia of the saddle area in which the prone position is mandatory

Materials

1 Standard spinal anesthetic set
2 Potent drug (pontocaine or nupercaine) which will yield a hypobaric solution in a small volume of distilled water
3 Sterile distilled water

Technique

1 *Position*
   a Place the patient in the prone position with the hips level with the "break" of the operating table
   b Place two pillows to support the lower part of the abdomen This eliminates the lumbar curve

Procedure

1 Prepare skin, raise an intradermal wheal, and anesthetize subcutaneous and interspinous tissues as for spinal anesthesia
2 Introduce the 19 gauge needle (short beveled) until it is well engaged in the interspinous ligament
3 Remove stylet and attach glass adapter to the needle The capillary tube should previously be filled with procaine solution
4 Request an assistant to arch back of patient well to accentuate the negative pressure in the epidural space
5 Advance needle into epidural space (a snap is felt as needle passes through interspinous ligament) The fluid in glass adapter is sucked inward due to negative pressure if the needle is in the epidural space (Fig 129) If fluid pours outward, it is in subarachnoid space *
6 Attach 20 cc syringe containing 10 cc 2% procaine to the needle and attempt aspiration
7 Rotate needle through an angle of 180° and aspirate once again
8 If no spinal fluid or blood is obtained, inject 10 cc of solution as rapidly as it flows (approximately 1 cc per minute)
9 Disconnect syringe, replace stylet, but do not allow patient to shift position or remove needle
10 Allow 5 minutes to elapse Test lower extremity for motor paralysis and analgesia If none exists and no other outward effects have appeared, it may be assumed needle is not in the subarachoid space and remainder of the drug may be safely injected
11 Withdraw stylet, attach syringe, and attempt aspiration once again Inject the remainder of the solution as rapidly as solution will pass into the epidural space
12 Withdraw needle and place the subject in the supine position for ab dominal surgery, Trendelenburg position (10°) for upper abdominal and Fowler's (5°) for pelvic surgery

Anesthesia

Onset Usually appears within 10 minutes and is completed within fifteen to twenty minutes

Distribution Motor anesthesia and sympathetic paralysis is only partial Sensory anesthesia of lower extremities and abdomen is complete Analgesia as far as clavicles may ensue

Duration One and a half to two hours The analgesia recedes gradually

* The negative pressure in the epidural space is not a constant finding Because of this Abajian has suggested attaching a small syringe containing 2 cc of normal saline solution to the needle just as it approaches the ligamentum flavum and exerting pressure upon the plunger The sense of re sistance felt on the plunger as the needle passes the ligament immediately disappears as entry into the epidural space is made and the liquid then flows freely The syringe is removed and the needle advanced cautiously until it is engaged in the epidural space

2 Caudal anesthesia This is obtained by introducing a needle through the sacrococcygeal membrane into the caudal canal

"SPINAL" EPIDURAL ANESTHESIA

Definition Anesthesia obtained by blocking the lumbar and thoracic spinal nerves in the epidural space

Uses

Anesthetic For operations upon the lower extremity and abdomen
Therapeutic For relief of intractable pain

Indications In cases in which the analgesia of spinal anesthesia is desired, but in which spinal anesthesia is contraindicated

Anatomy The epidural space extends from the coccyx to the foramen magnum The dura, at the foramen splits into two layers, an external and an internal The external layer covers the bony surfaces of the spinal canal and corresponds to the periosteum The internal layer covers the cord and is actually the true dura The space which lies between the two layers is epidural space It is filled with fat and a plexus of veins When the back is arched sharply, a negative pressure develops in the space The cord ends at L 2, the dural sac at S 2 (Fig 128)

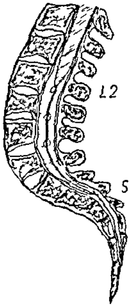

Fig 128 Cross section of lower portion of spinal column Note spinal cord ending at (L 2) and dural sac at (S 2)

Materials Same as for spinal anesthesia, but in addition provide

1 One 20 cc syringe which can be attached to a 19 G short bevel spinal needle
2 A container to act as reservoir for local anesthetic solution (100 cc)
3 A glass connecting tip or observation tube which fits into the hub of spinal needle provided with a bore of small calibre 0 5 to 1 mm

Dosage Procaine hydrochloride 2% solution

a 35 cc for perineal and low pelvic surgery
b 45 cc for lower abdominal surgery
c 50 cc for upper abdominal surgery

Technique

1 *Position*
 a Lateral prone as for spinal anesthesia This is the preferred position
 b Upright sitting
2 *Landmarks* 2nd or 3rd lumbar interspaces

Procedure

1 Prepare skin, raise an intradermal wheal, and anesthetize subcutaneous and interspinous tissues as for spinal anesthesia

2 Introduce the 19 gauge needle (short beveled) until it is well engaged in the interspinous ligament

3 Remove stylet and attach glass adapter to the needle The capillary tube should previously be filled with procaine solution

4 Request an assistant to arch back of patient well to accentuate the negative pressure in the epidural space

5 Advance needle into epidural space (a snap is felt as needle passes through interspinous ligament) The fluid in glass adapter is sucked inward due to negative pressure if the needle is in the epidural space (Fig 129) If fluid pours outward, it is in subarachnoid space *

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12 Withdraw needle and place the subject in the supine position for abdominal surgery, Trendelenburg position (10°) for upper abdominal and Fowler's (5°) for pelvic surgery

Anesthesia

Onset Usually appears within 10 minutes and is completed within fifteen to twenty minutes

Distribution Motor anesthesia and sympathetic paralysis is only partial Sensory anesthesia of lower extremities and abdomen is complete Analgesia as far as clavicles may ensue

Duration One and a half to two hours The analgesia recedes gradually

* The negative pressure in the epidural space is not a constant finding Because of this Abajian has suggested attaching a small syringe containing 2 cc of normal saline solution to the needle just as it approaches the ligamentum flavum and exerting pressure upon the plunger The sense of resistance felt on the plunger as the needle passes the ligament immediately disappears as entry into the epidural space is made and the liquid then flows freely The syringe is removed and the needle advanced cautiously until it is engaged in the epidural space

Complications

1 The needle may enter subarachnoid space and the total dose be inadvertently injected there This is approximately 10 times the average dose for spinal anesthesia
2 The needle may enter one of the intraspinal veins and an intravascular injection results

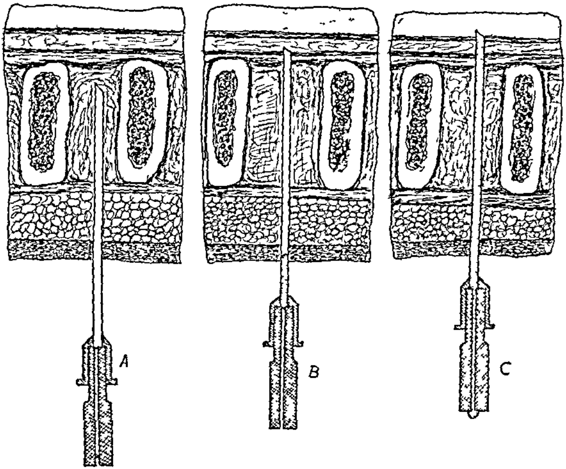

Fig 129 Method of performing lumbar epidural block (A) Needle and glass adapter The capillary tube is filled with procaine solution (B) Needle in epidural space Note aspiration of fluid from the glass adapter into the needle and epidural space This is caused by the negative pressure in the epidural space (C) Needle in subarachnoid space Flow of the spinal fluid indicates needle has been advanced too far

3 Segmental (spotty) anesthesia may result
4 Hypotension if motor paralysis is intense and widely distributed (as for spinal anesthesia)
5 Reaction due to hypersensitivity or rapid absorption of the drug

Advantages

1 Duration of action is prolonged compared to spinal anesthesia
2 The drug diffuses from the epidural space along the course of the nerve and anesthesia comparable to paravertebral block results

3 There is no contact between the bare nerve roots or cord and drug as in spinal anesthesia
4 The drug cannot pass into the medullary region because the epidural space ends at the foramen magnum
5 Headaches infrequent in comparison to spinal anesthesia
6 Danger of meningitis or encephalitis or other neurological complications is minimized compared to spinal anesthesia

Disadvantages

1 The placement of the needle in the epidural space is difficult to verify The danger of entering the subarachnoid space and depositing an overdose of local anesthetic drug is ever present
2 Muscle relaxation is inadequate and unsatisfactory
3 Level of analgesia is difficult to control and unpredictable
4 Large quantities of drug are necessary to secure anesthesia (almost one gm of procaine)
5 Drug may not penetrate each of the nerves concerned with similar facility or ease and anesthesia is incomplete or segmental

Comment	*Reasons*
1 Withdraw the needle and reinsert into different interspace if spinal fluid is obtained	Spinal anesthesia may result if injection is attempted after puncturing the arachnoid
2 Treat hypotension in the same manner as that which accompanies spinal anesthesia	The mechanism of its production is similar to that which accompanies spinal anesthesia
3 Observe the same precautions described for lumbar puncture in introducing the needle	The technique is essentially the same in both cases
4 Do not omit premedication particularly if patients are apprehensive	The intensity of anesthesia and analgesia is not profound and the patient may have some sensation
5 Do not fail to administer a barbiturate preoperatively	This minimizes reactions to the local anesthetic drug
6 Always perform the puncture in the midline	Trauma to the meningeal vessels is avoided
7 Always employ a needle with a short bevel	A long bevel may partially enter the subarachnoid space as well as epidural space
8 Do not arch back until the needle enters the epidural space	This prevents dilatation of the veins in the space
9 Always perform the puncture in the lumbar region	The epidural space is larger in this area
10 Do not employ weak solutions of procaine (less than 2%)	The dura passes over the nerves as a sheath in the epidural space,

	and the drug penetrates this with difficulty
11 Insert stylet to clear the needle before solution is injected	Some tissue may have entered the lumen while the needle was traversing the ligament

Variations in Technique

1 Epinephrine (0 75 cc of a 1 1000 solution) may be added to the procaine to prolong anesthesia Its use may be accompanied by systemic disturbances from the sympathetic stimulation
2 Pontocaine, 10 mgm in 50 cc of 2% procaine, may likewise be added to prolong anesthesia, but its use is accompanied with more danger
3 Intracaine, 2% in saline, lidocaine 1% or metycaine 1 1/2% or pontocaine 0 1% may be used instead of procaine
4 2% procaine or intracaine base in sweet almond oil may be employed for therapeutic purposes

Segmental Epidural Analgesia

Segmental epidural analgesia may be accomplished by introducing the needle in the lumbar or thoracic vertebral interspaces corresponding to the spinal segments desired and injecting 20 to 25 cc of 2% procaine Blocking of the desired pathways at these selected levels of the cord obviates filling the entire epidural space with drug and limits the extent of anesthesia (see Abajian, J , listed below)

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Odom, C B Epidural Anesthesia Am J Surg , *34* 547–558, December, 1936
Odom, C B *A Review of Pages' Epidural Anesthesia with a Report of 100 cases* New Orleans M & S J , *88* 618–627, April, 1936
Tovell, R M , and Hinds, C B Abdominal Block with General Anesthesia for Upper Abdominal Surgery J A M A , *115* 1690–1692, November 16, 1940

Caudal Anesthesia

Definition Caudal block is a block of the lumbosacral and coccygeal plexus obtained by depositing a solution of local anesthetic drug in the epidural space in the sacral canal The nerves are bathed as they emerge from the dural sac

Synonym Caudal, peridural, or extradural block

Uses

1 *Anesthetic*
  a Urological operations (except those involving the dome and the sides of the bladder This portion of the bladder is innervated by the vesical plexus, which arises from the hypogastric plexus)
  b Rectal operations

c Perineal operations (except those involving the clitoris and the dorsal surface of the penis, their innervations are derived from the hypogastric plexus)

d Obstetrics

2 *Therapeutic*

a Relief of acute sciatica

Anatomy The sacrum is a wedge shaped bone jointed by ligaments to either side of the ilium (Fig 130) The upper surface or apex is attached to the coccyx The sacrum is formed from five fused modified vertebrae The posterior surface of the sacrum is irregular, convex upward and backward and presents on two sides two rows of openings, each known as the

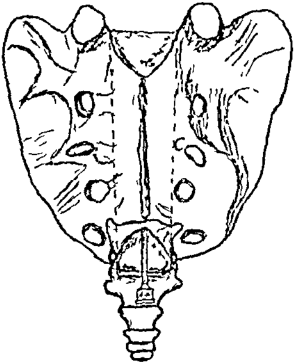

Fig 130 Dorsum of the sacrum showing the caudal needle in the sacral canal Note that the sacral hiatus lies between the sacral cornua and that the needle is not introduced beyond the level of the second sacral foramina (C)

posterior sacral foramina, through which the posterior primary divisions of the sacral nerves pass to the region of the dorsum of the sacrum The first four foramina, about one cm in diameter and almost parallel with the midline, are inclined inward to follow the margin of the bone A spinous crest which is the remnant of the spinous process is present on the midline from S_1 to S_4 The fifth spinous process is absent and leaves an opening at the apex called the sacral hiatus which is "V" shaped The hiatus is bounded on either side by two prominences or sacral cornua which are used to identify the hiatus The anterior surface of the sacrum is smooth, triangular, and concave and presents two rows of foramina,

the anterior sacral foramina through which the anterior primary divisions of the nerves pass The anterior and posterior foramina face each other and communicate with a canal, lying within the sacrum called the sacral canal The sacral hiatus which is the entrance to this canal, is covered by a thick membrane, the sacrococcygeal membrane The dural sac, which encloses the filum terminale, ends at the level of the second sacral foramina The second sacral foramina is approximately one cm caudad and one cm medial to the posterior superior iliac spine The nerves involved during caudal block are those arising from (a) the sacral plexus This is formed by L_4, L_5, S_1, S_2, and S_3 (the anterior primary divisions) From the anterior and posterior surface of this plexus numerous branches are given off, but the main portion of the plexus is continued as the sciatic nerve, (b) the pudenal nerve This derives its branches from the anterior divisions of S_2, S_3, and S_4 (c) The coccygeal plexus This derives its branches from the anterior divisions of S_4 and S_5 and the coccygeal nerve The posterior primary divisions of these various nerves are also blocked in caudal block

Materials

1 In addition to the standard nerve block tray, the following materials are necessary
2 One 18 or 19 gauge (10 cm) semi flexible needle
3 One 10 cc syringe which fits the needle Select a type satisfactory for regional anesthesia

Technique

1 *Position*
   a Place the patient in the prone position with a pillow under the hips to elevate the sacrum The operator should stand at the patient's left side This position is preferred
   b In Sims or knee chest position for obstetrics
2 *Landmarks*
   a *The coccyx* This may be palpated in the gluteal cleft with the right index finger at the base of the vertebral column
   b *The sacro coccygeal joint* The depression felt at the joint corresponds to the sacral hiatus It may be palpated by drawing the finger cephalad over the coccyx
   c *The sacral cornua* These represent the inferior articular process of the fifth sacral vertebra The cornua mark the lateral boundaries of the sacral hiatus
   d *The second sacral foramina* Palpate the posterior superior iliac spine Measure and mark a point on the skin one cm caudad and one cm medially This point overlies the foramen

3 *Procedure*

a Locate and mark both sacral cornua and the second sacral foramina

b Raise an intradermal wheal at a point midway between the cornua This overlies the sacral hiatus

c Inject 1/2 cc of anesthetic solution into the subcutaneous tissues and the sacrococcygeal membrane

d Locate and mark both second sacral foramina

e Place the needle along the sacrum and mark off the distance between the foramina and the cornua

f Stretch the skin over the hiatus with the thumb and index finger of the left hand to facilitate puncture

g Grasp the needle (with the stylet in place) with the thumb and index finger of the right hand and pierce the wheal so that an angle of 45° is made with the skin overlying the sacrum (Fig 131)

h Advance the needle to the sacrococcygeal membrane which is encountered approximately 3/4 cm from the skin surface

i Swing the hub of the needle downward to an angle of approximately 20° to the surface of the sacrum (Fig 131)

j Pierce the sacrococcygeal membrane and introduce the needle into the sacral canal, as far as the marker

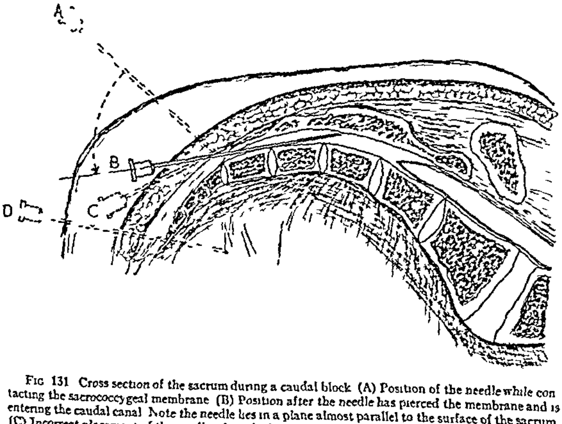

FIG 131 Cross section of the sacrum during a caudal block (A) Position of the needle while contacting the sacrococcygeal membrane (B) Position after the needle has pierced the membrane and is entering the caudal canal Note the needle lies in a plane almost parallel to the surface of the sacrum (C) Incorrect placement of the needle when the hiatus is inaccessible or missed The needle lies upon the surface of the sacrum (D) The needle is shown in the pelvis This occurs if the tip of the coccyx is mistaken for the sacrococcygeal joint. Note the position of the dural sac

k Withdraw the stylet, attach the syringe and attempt aspiration Rotate needle and attempt aspiration once again If no blood or spinal fluid is obtained, introduce 5 cc of 2% procaine slowly into the canal The solution should pass in freely with slight pressure on the plunger if the needle is in the canal Place the hand upon the dorsum of the sacrum during the injection to note the appearance of tumefaction which indicates the needle is subcutaneous rather than in the canal

l Remove the syringe from the needle and replace the stylet Watch closely for toxic reaction or the appearance of spinal anesthesia

m Allow five minutes to elapse and, if no untoward reaction appears, inject the remainder of the procaine solution (20 cc) slowly into the canal Aspiration should be done frequently during the injection

n Withdraw the needle from the canal, but not completely from the subcutaneous tissue Divert it towards each cornua, first one side then the other, and inject 1/2 cc of solution into the fifth sacral foramen This blocks the fifth sacral nerve which emerges beneath the cornua

Anesthesia

1 Onset gradually appears in 10 to 15 minutes
2 *Distribution*
   a Complete anesthesia of the anal sphincter, structures about the anus, structures over the sacrum, vagina, labia majora and minora, the under surface of the penis, the scrotum, the bladder (except the dome), the urethra, the cervix, and the lower uterine segment Partial anesthesia is obtained over the outer under surface of the foot and a band extending along the posterior aspect of the leg Muscles of pelvic floor are relaxed
3 *Duration*
   a From one to two hours

Complications

1 Intravascular injection The peridural space in the sacral canal is lined with a rich plexus of veins anyone of which may be pierced by the needle
2 Intraspinal injection Spinal anesthesia results This is caused by ad vancing the needle beyond the level of the second sacral foramina into the dural sac (Fig 131)
3 Piercing of rectum The needle is inserted through the anococcygeal ligament if incorrect landmarks are chosen (Fig 131)
4 Subperiosteal injection No anesthesia is obtained The solution is in jected with difficulty

5 Local infections or peridural abscess To prevent these, asepsis must be rigidly observed
6 Broken needle in the caudal canal Test all needles before performing the block

Contra Indications

1 Distortion of the bony landmarks, by arthritis, old fractures, tuberculosis, neoplasms, etc
2 The presence of local infection at the site of injection
3 For emotionally unadjusted patients
4 For prolonged operations
5 Aspiration of blood or spinal fluid after introducing the needle in attempting block Select another technique of anesthesia

"High" Caudal Anesthesia

Definition An epidural block produced by the injection of a large volume of local anesthetic solution into the caudal canal so that it diffuses into the lumbar or thoracic peridural space

Uses

1 For urological operations, such as on the dome of the bladder or of the suprapubic type
2 For operative obstetrics

Procedure The procedure for "high caudal block" is similar to caudal block with the exception that a larger volume of fluid is necessary to force a sufficient amount of fluid to involve the nerves in lumbar or thoracic regions

Technique

1 Proceed exactly as described for caudal block Insert the needle in usual manner, and inject 5 cc of 2% procaine
2 Allow 5 minutes to elapse as in caudal block
3 Inject 50–60 cc of 2% procaine instead of 25 or 30 and follow directions and precautions as for caudal block

Comment on Caudal Block	*Reasons*
1 Do not proceed with the block if spinal fluid or blood is aspirated into the syringe	The drug may pass into the subarachnoid space or into the vascular system
2 Treat hypotension by means of ephedrine or other vasopressor in the same manner as hypotension in spinal anesthesia	The mechanism producing it is similar to that caused by spinal anesthesia

3 Remember that the drug leaves the peridural space by diffusion along the spinal nerves	The drug does not diffuse through the dura
4 Always allow twenty minutes between completion of the block and scheduled time of operation	Satisfactory anesthesia is not complete in less than twenty minutes
5 Always rotate the needle and attempt aspiration twice	The needle tip may be in a vein and pressed to the bony surface This prevents aspiration of blood and would be misleading if aspiration is attempted only once
6 Place a gauze sponge in the intergluteal fissure in preparing the patient	Antiseptic solutions employed to prepare the skin are prevented from spreading to anus and genitalia

Causes of Failure of Caudal Block

1 Inability to correctly introduce the needle into the sacral canal This may be due to
   a Absence of reliable landmarks
   b Impermeability of sacrococcygeal membrane to the needle
   c Distortions of sacrum due to disease
2 The solution employed is insufficient in volume or weak in strength
3 The sacral canal is large and the volume of solution is not sufficient to fill it
4 Bleeding within canal due to trauma to veins interferes with diffusion of the drug
5 The injection was made into subcutaneous tissues or posterior aspect of sacrum because needle is not properly placed
6 The injection was made into the pelvis because needle was inserted through sacrococcygeal ligament at tip of coccyx instead of at sacrococcygeal joint
7 The neural sheaths are too dense or impermeable to the drug
8 The dura may be adherent to the periosteum and does not allow the drug to pass into the lumbar epidural space (The dura is frequently adherent at the lumbosacral joint)

REFERENCES

Labat, Gaston Regional Anesthesia P 496 Philadelphia W B Saunders Co , 1922
Lundy, J S A Method for Producing Block Anesthesia of the Sacral Nerves Am J Surg , *4* 262–270, March 1928
Tuohy, Edward B Regional Block Anesthesia for Operations on the Perineum, Anus, Genitalia and Lower Extremities *2* 369–387 July, 1941

"Continuous" or Repeated Caudal Block

Definition Caudal block, either high or low, which may be sustained over a long period of time by allowing the needle to remain *in situ* and repeating the injection of drug

Uses

1. *Obstetrics* For relief of pain of labor and operative procedures.
2. *Urological or gynecological and rectal surgery* For prolonged operations upon the perineum, rectum, or genitalia

Materials Same as for caudal by single injection, but in addition provide

1. One three way stopcock (Luer) or one way valve (Fig 132)
2. One length of thick walled rubber tubing 4 feet long, equipped with Luer lock hub which fits the caudal needle at one end and the stopcock or one way valve at the other
3. One length of similar tubing 2 inches long equipped with adapter for attaching the syringe
4. One wide mouth sterile glass receptacle of approximately 500 cc capacity (preferably calibrated) (Fig 132)
5. One rubber stopper with two perforations to fit the glass receptacle (Fig 132)

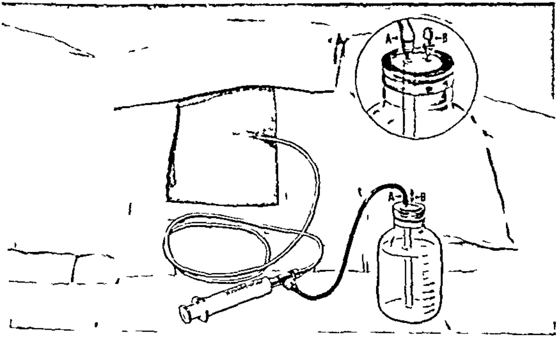

Fig 132 Assembly for continuous caudal anesthesia The needle is a special one made of malleable metal. Note knob near hub which acts as a guard The tube connecting the needle with the valve and syringe must be at least four feet long and must have a thick wall because *it will be subjected to considerable pressure* Soft rubber tubing is used for connecting the valve to the reservoir for the local anesthetic solution (Courtesy Dr Robert A Hingson)

6 One piece of glass tubing approximately 3/16" in diameter, bent at right angles to fit the stopper and slide in the full length of the glass receptacle or a 15 gauge long aspirating canula with hose type connection (Fig 132)
7 One 18" length of rubber tubing to fit end of stopcock and glass receptacle (Fig 132)
8 Gauze, or felt pad to protect needle
9 Special 19 gauge malleable needle and stylet (Fig 132)
10 One 10 cc syringe with Luer lock

Technique

1 *Landmarks* are the same as for caudal block by single injection
2 *Position* is the same as for caudal block by single injection
3 *Procedure*
   a Arrange apparatus as shown in Fig 132
   b Prepare patient as described for caudal block
   c Introduce special needle in same manner as described for caudal block
   d Remove stylet from needle, attach 2" tubing to hub
   e Attach syringe and attempt aspiration as described in caudal block
   f Introduce 10 cc 2% procaine or equivalent of other preferred drug, replace stylet and allow 5 minutes to elapse as in caudal block
   g Expel air from long tube by filling with solution and attach it to the hub of the needle
   h Attempt aspiration frequently during injection
   i Close stopcock, secure needle with adhesive after padding hub well with gauze or felt
   j Place patient in a comfortable position
   k Repeat the injection when the diminution of analgesia is becoming apparent Successive doses should be introduced in the same manner and with the same care as the initial dose

Anesthesia

1 *Onset* Same as in caudal block by single injection
2 *Duration* Same as in caudal block by single injection Repeat as often as necessary using same volume as for initial injection
3 *Extent* May be high or low, depending upon need of individual cases May be controlled by varying volume of fluid 30 cc for low (perineal), 45 cc for medium (suprapubic) and 60 cc 2% procaine for high (abdominal) anesthesia

Advantages Same as for caudal block by single injection, except that duration may be prolonged

Complications

1 These are the same as for caudal block, but the following additional objections are offered

a Needle may break in canal

b The needle may shift position and enter a vessel or the dura

c Tissues may be injured from repeated or prolonged exposures to the local drug

d Asepsis is not easily maintained and peridural or local abcesses form

e A sense of fullness in sacrum or pain in legs may accompany injection of the drug This soon passes away

Contra Indications Same as for caudal block

Remarks

1 The anesthetist should attend the patient constantly Repeated doses should be administered by a physician
2 Individualize the dosage and frequency of injection
3 Exercise the same precautions in subsequent injections as at the initial injection
4 Repeat premedication if patient becomes apprehensive during surgery
5 Cleanse skin in area of injection thoroughly to avoid infection
6 Add epinephrine 0 75 cc of a 1 to 1000 solution to each 50 cc of the drug to prolong its action and inhibit absorption

Continuous Caudal Anesthesia in Obstetrics

Procedure A "high" caudal block is performed in the manner described above, so that epidural anesthesia involving the lumbar segments (or higher) is induced to produce relief of pains of labor

Advantages

1 Complete relief of pain if the block is "high "
2 Uterine contractions are not abolished and labor continues
3 Relaxation of muscles of pelvic floor is excellent and facilitates and quickens labor Dilatation of the cervix is facilitated
4 Respiratory and other functions of fetus are not depressed
5 Patient is conscious and retains normal faculties
6 Metabolic and other functions are not disturbed

Disadvantages

1 Unavoidable failures due to technical difficulties or anatomical distortions limit its use
2 Bladder urge is lost and urine leaks with each uterine contraction

3 Analgesia may mask ensuing complications, such as rupture of uterus
4 Circulatory failure or depression may occur if anesthesia is intense
5 Toxic reactions may occur from rapid absorption of the drug
6 Labor is retarded if ascent of anesthesia extends beyond Th 10
7 Greater incidence of instrumental deliveries
8 Malpositions, particularly posterior presentations, do not correct themselves

Contra-Indications

1 Subjects in whom disproportion between size of fetus and canal exists
2 Cases of placenta praevia
3 The presence of deformities of spine or sacrum or other anatomical distortions
4 The presence of local infection in vicinity of sacrum
5 Versions and similar type of operative obstetrics
6 Cases of hypotension

Remarks

1 Inject one full dose of the drug at time of delivery if the interval ensuing between it and previous injection is more than thirty minutes
2 Disconnect the tube, replace stylet but leave needle in place during delivery Inject another volume of drug if required

REFERENCES

Edwards Waldo B , and Hingson, Robert A The Present Status of Continuous Caudal Analgesia in Obstetrics Bulletin of the New York Academy of Medicine, *19* 507, July 1943

Hingson, Robert A , and Edwards, Waldo B *Comprehensive Review of Continuous* Caudal Analgesia for Anesthetists Anesthesiology, *4* 181, March, 1943

ALTERNATE TECHNIQUE FOR CONTINUOUS CAUDAL ANESTHESIA

Description A French ureteral or plastic catheter is inserted into the caudal canal instead of a malleable needle

Materials In addition to the materials described above supply

1 One #5 ureteral or plastic catheter 30″ long
2 One #13 gauge needle 8 cms long which will accommodate catheter
3 One needle #22 gauge or size to fit into ureteral catheter

Technique

1 Proceed as above and introduce 13 gauge needle into the caudal canal
2 Thread the catheter into the needle if no blood or spinal fluid are obtained by aspiration

3 Withdraw needle in such a manner that the catheter is not disturbed and remains in the caudal canal Fasten securely with adhesive
4 Insert the 22 gauge needle into the free end of the catheter, attach the syringe and inject procaine as described in the technique above

Technique Using Drugs Other than Procaine

1 An equivalent volume of 1 5% metycaine may be substituted for procaine—duration 1 ½-2 hrs
2 An equivalent volume of 0 10% pontocaine in physiological saline may be substituted for procaine—duration 2 ½-4 hrs

REFERENCE

Adams, R C, Lundy, J S, and Seldon, T H A Technique for Continuous Caudal Anesthesia and Analgesia Surgical Clinics North America, *23* 1196, August, 1943

PARAVERTEBRAL BLOCK ANESTHESIA

Definition Anesthesia induced by distributing a solution of local anesthetic drug about the bodies of the vertebrae and infiltrating the nerve trunks as they emerge from the intervertebral foramina

Types

1 Cervical paravertebral block
2 Thoracic paravertebral block (see below)
3 Lumbar paravertebral block (see below)
4 Transacral block

Indications

1 *Anesthetic* For operations in areas innervated by the various nerve segments which are accessible for this type of block
2 *Diagnostic* To produce sympathetic block to differentiate diseases of autonomic nervous system from other conditions
3 *Therapeutic* To relieve vasospasm, neuritis, or other types of segmental pains

Anatomy See individual blocks that follow

Materials Standard regional set This should include one needle for each nerve to be blocked

Technique

1 *Position* Either of two positions may be employed
   a Place the patient in the lateral prone position lying on the side opposite to the one to be injected Place a pillow beneath the loin to straighten vertebral column

3 Analgesia may mask ensuing complications, such as rupture of uterus
4 Circulatory failure or depression may occur if anesthesia is intense
5 Toxic reactions may occur from rapid absorption of the drug
6 Labor is retarded if ascent of anesthesia extends beyond Th 10
7 Greater incidence of instrumental deliveries
8 Malpositions, particularly posterior presentations, do not correct themselves

Contra Indications

1 Subjects in whom disproportion between size of fetus and canal exists
2 Cases of placenta praevia
3 The presence of deformities of spine or sacrum or other anatomical distortions
4 The presence of local infection in vicinity of sacrum
5 Versions and similar type of operative obstetrics
6 Cases of hypotension

Remarks

1 Inject one full dose of the drug at time of delivery if the interval ensuing between it and previous injection is more than thirty minutes
2 Disconnect the tube, replace stylet but leave needle in place during delivery Inject another volume of drug if required

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Hingson Robert A , and Edwards Waldo B Comprehensive Review of Continuous Caudal Analgesia for Anesthetists Anesthesiology, *4* 181, March, 1943

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Materials In addition to the materials described above supply

1 One #5 ureteral or plastic catheter 30″ long
2 One #13 gauge needle 8 cms long which will accommodate catheter
3 One needle #22 gauge or size to fit into ureteral catheter

Technique

1 Proceed as above and introduce 13 gauge needle into the caudal canal
2 Thread the catheter into the needle if no blood or spinal fluid are obtained by aspiration

2 *Landmarks*
  a Condyle of the mandible of the jaw
  b Surface of the second lower molar tooth
  c Transverse processes of the cervical vertebrae
3 *Procedure*
  a Palpate, bisect, and mark the point of bisection of the condyle of mandible of the jaw (A, Fig 133)
  b Draw a line through the condyle perpendicular to the operating table (B, Fig 133)
  c Draw a horizontal line perpendicular to the vertical one along the transverse processes of the vertebral column (C, Fig 133)

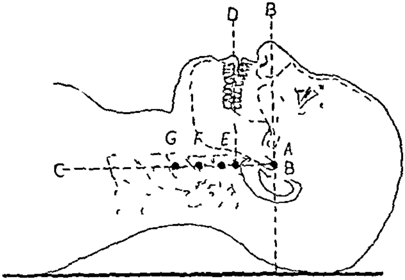


Fig 133 Landmarks for cervical plexus block (A) Condyle of mandible (E) (F) (G) 2nd 3rd and 4th cervical vertebrae respectively

  d Drop a second perpendicular line passing along the surface of second molar tooth Mark the point on the skin where this line intersects the horizontal line (D, Fig 133)
  e Mark the skin one cm below this point along the horizontal line (E Fig 80) This corresponds to the second cervical vertebrae Mark skin also 2 1/2 cms and 3 1/2 cms below this first point These points correspond to third and fourth cervical vertebrae Four points are thus indicated (F, G, Fig 133)
  f After the landmarks are located, turn head to one side and raise intradermal wheals on the lower three marks on skin
  g Insert 5 cm needle perpendicular to the skin Set marker at 1 1/2 cms and establish contact with the anterior tubercle of transverse process Inject 5 cc of 2% procaine at this site
  h Repeat the procedure on the points indicating the third and fourth cervical vertebrae Establish contact with the anterior tubercle as

b Place the patient in the prone position with pillow beneath thorax or abdomen depending upon the block to be performed

2 *Landmarks*

a Spines of the vertebrae

b Transverse process of the vertebrae (or ribs in thoracic block)

3 *Procedure* See individual blocks that follow

Cervical Plexus Block

Definition Anesthesia obtained by blocking the cervical nerves as they emerge from the vertebral column

Synonyms Paravertebral cervical block

Types

1 Lateral approach (most common)

2 Posterior approach (employed when the lateral route is not practical)

Indications

1 *Diagnostic* For differentiation of neuralgias (hypoglossal) or for carotid sinus syndrome

2 *Anesthetic* For operations on the neck

Anatomy The anterior primary divisions of the first four cervical nerves emerge from the cervical intervertebral foramina, pass behind the vertebral arteries and then to the tip of the transverse processes of the vertebrae The transverse processes of the cervical vertebrae have two tubercles, an anterior and a posterior These tubercles lie from 1–2 cms below the skin surface As the nerves pass through the sulcus formed by the tubercles, they divide into an ascending and descending branch which connect with each other to form a series of loops known as the cervical plexus, the plexus which lies beneath the sterno mastoid muscle Each loop gives rise to two branches a *superficial* which emerges at the posterior edge of the sterno mastoid and supplies the skin and other superficial structures, and the *deep* which supplies the muscles and other deep structures of the neck

Materials Standard regional set The set should be provided with two 8 cms needles (22 G) and six 5 cms needles (22 G)

Lateral Approach

Technique

1 *Position* Place the patient in the supine position with the chin pointing upward (no pillow) The operator should stand on the side which is injected

Paravertebral Block—Thoracic Region

Definition A block of the spinal nerves of the thoracic region accomplished by injection of a local anesthetic solution in the paravertebral area

Indications

1 *Diagnostic and therapeutic* Coronary pain, causalgias, neuralgias of the intercostal nerves
2 *Anesthetic* For thoracic surgery or superficial operations on thorax The block is employed in conjunction with cervical plexus or lumbar block It is rarely employed alone

Anatomy Each of the twelve thoracic vertebra consists of a body, a spinous and two transverse processes The latter articulate with the ribs The spinous processes of the thoracic vertebrae are not natural landmarks for their homologous nerves or intervertebral spaces The spinous processes increase in length and slope downward as they descend from the upper to the lower vertebrae Therefore, the spine may point to the rib or interspace below the designated vertebrae In the erect posture, with the arms lying along the side of the trunk, a line joining the spines of the scapulae passes through the third thoracic spine, a line joining the lower angles of the scapulae passes through the seventh thoracic spine These landmarks are subject to displacement or variations of the scapulae A line 5 cm long drawn from a point along the twelfth rib perpendicular to the midline of the back will mark the spine of the twelfth thoracic vertebra The spine of the seventh cervical vertebra is the most prominent in the upper part of the vertebral column

Each thoracic nerve emerges from the intervertebral foramen and divides into an anterior and posterior primary division after having first given off the meningeal nerve to the dura and vertebrae The posterior primary division supplies the muscles and skin of the back, the anterior gives off the ramus communicans to the sympathetic ganglion after which it passes into the paravertebral space The thoracic nerves lie midway between the transverse processes of the two vertebrae as it emerges from the intervertebral foramen The nerve passes toward the rib above it and enters the intercostal groove

Technique

1 *Position* The patient may be placed in one of two positions
   a Lateral prone with patient lying on side opposite to one to be blocked (as for spinal anesthesia)
   b Prone with pillow beneath thorax
2 *Landmarks*
   a Spinous process of the thoracic vertebrae above the spinal nerve to be injected

in the previous vertebrae Inject 4 cc of 2% procaine at these sites
i Inject 10–15 cc of 1% procaine along posterior border of the sterno mastoid muscle in subcutaneous tissues
j Repeat the injection on opposite side using exactly the same technique if a bilateral block is desired

Anesthesia

1 *Onset* Usually within 5–10 minutes if procaine is employed
2 *Distribution* Lateral and anterior superficial and deep structures of neck Also the skin on posterior aspect of neck, occiput and a capelike distribution over the shoulders extending to the level of the second rib
3 *Duration* One hour, approximately

Complications

1 The carotid sheath may be pierced by prevertebral injections and signs of vascular compression ensue
2 The carotid artery may be entered by the needle
3 The needle may enter the spinal canal and even pierce the dura
4 An intravenous injection may be performed This area is highly vascular

Precautions Do not inject drug in front of the transverse process

Contra Indications

1 Infections of the neck
2 Tracheal obstruction

Comment

1 The first cervical nerve is not anesthetized in this procedure
2 The fourth cervical nerve is blocked but the motor power of the diaphragm remains intact or a paresis results The diminished ventilation due to the paresis is compensated for by the increase in intercostal activity
3 The transverse process of the cervical vertebrae is thin and the needle point easily slips from its surface
4 The sympathetic nerves are also affected by the block and a Horner's syndrome frequently appears
5 The lower cervical vertebrae become progressively superficial The needles therefore need not be inserted as deeply in seeking their tubercles

REFERENCE

Rovenstine E A, and Wertheim H Cervical Plexus Block New York State J Med *39* 1311 1939 *

* This technique originally described by these workers

d 10th region of umbilicus, level of respective vertebrae posteriorly
e 11th
12th area between umbilicus and pubis

Complications

1 The drug may be accidentally injected into the subarachnoid or epi dural space
2 The drug may be injected into an intercostal artery or vein
3 The needle may pierce the pleura and the lung

Precautions

1 Always rely upon the marker when seeking the depth of a bony land-mark
2 Always inject the drug slowly at first Withdraw the needle if patient coughs or if blood, air, or spinal fluid is obtained

Contra Indications

1 Infections in the area of injection

Comment

1 Note that the cutaneous nerves overlap Therefore, several segments must be anesthetized to obtain an effective block
2 Remember that the anesthesia does not extend to the midline, but ends approximately an inch from it due to overlapping of filaments from the thoracic nerves on the opposite side
3 Note that in the upper portion of the thorax, the cervical nerves over-lap into the area supplied by the first three of four thoracic segments Therefore, the block must be supplemented by a cervical block or local infiltration
4 Always test the field of anesthesia after the blocks are performed Supplementary injection of an upper or lower segment, depending upon the case will be necessary if the area of anesthesia is not suf ficiently extensive
5 Do not introduce the needle beyond the distance designated by the marker
6 Note that the ribs may lie as many as 5 cms below the skin surface in obese or muscular subjects

CERVICO THORACIC SYMPATHETIC BLOCK (STELLATE GANGLION BLOCK)

Definition A paravertebral block of the lowest portion of the cervical sym pathetic chain

b Transverse process of the same vertebrae or the rib attached to it depending upon the size of the vertebrae

3 *Procedure*

a Draw a line 4 cm from and parallel to the midline of the vertebral column (Fig 134)

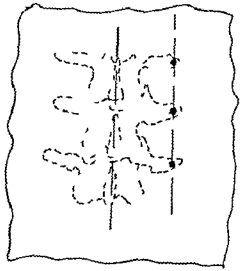


Fig 134 Method of inducing paravertebral block Wheals are raised over the transverse processes of the vertebrae at the level of the corresponding spines The vertebrae are seen from the back

b Palpate the spinous processes of the vertebrae above the spinal nerves supplying the segmental areas to be blocked and mark their level on the line described in step a

c Raise intradermal wheals on a level with the desired spinous processes Bear in mind that the corresponding rib may not be in direct line with the processes in the lower thoracic region

d Introduce an 8 cm needle (with the marker set at approximately 2 5 cm from the tip) in a direction perpendicular to the skin until rib is encountered

e Set the marker another 2 5 cm upward on the shaft of the needle Advance the needle at an angle 45° downward (caudad) so that it glances off the edge of the rib

f Withdraw the needle almost to the skin and reinsert it towards the lower edge of the rib

g Advance the needle one cm into the space between the transverse processes and inject 5 cc of 1% procaine Repeat procedure on the opposite side if a bilateral block is desired

Anesthesia

1 *Onset*

a Usually within five minutes if procaine is employed

2 *Distribution*

a 1st thoracic nerve is part of the brachial plexus

b 2nd
3rd heart and nipple and chest wall anteriorly
4th level of the respective vertebrae posteriorly
5th

c 6th
7th anterior wall of abdomen above umbilicus
8th level of the respective vertebrae posteriorly
9th

transverse process Introduce the needle approximately 5–6 cms Use marker

d Withdraw needle slightly and reinsert in a caudad direction and medially towards body of vertebra so that it slips off the transverse process

e Incline the needle so that it forms an angle of 20–30° with the median sagittal plane Insert until the body of first thoracic vertebra is encountered (a distance of 5–8 cms)

f Turn the needle so that bevel is in contact with the body of the vertebra

g Advance needle along the lateral aspect of the vertebra until contact with bone is lost

h Place a drop of procaine solution on the hub of the needle head and ask patient to breathe If needle is in pleural space, bubbles will be observed

i Inject 5 cc 2% or 10 cc 1% procaine in divided doses over a period of several minutes

j Allow needle to remain in place if the procaine is to be followed by alcohol

k Inject 2–5 cc of absolute alcohol (see page 314)

Anesthesia

1 *Onset* Five to 15 minutes if procaine is employed

2 *Distribution* If the block is successful, Horner's syndrome results The following signs are noted

Miosis
Enopthalmos
Narrowed palpebral fissure
Hypoidrosis on face and arms of affected side
Increased skin temperature on affected side
Injection of conjunctiva

3 *Duration* Varies

Complications

1 The needle may pass into the pleural space especially on the right side and produce a pneumothorax

2 The subarachnoid space may be entered and an intraspinal injection result

3 The needle may enter a vessel and intravascular injection result

Precautions

1 Always attempt aspiration to obtain blood or spinal fluid

2 Always perform test using drop of procaine solution in hub of needle to determine if needle is in pleura

Types

1 Posterior approach This is the least commonly employed route
2 Anterior approach This route is commonly employed
3 Lateral approach } The subclavian vessels are too close to path of the
4 Superior approach } needle These routes are not frequently employed

Indications

1 *Diagnostic* Not important Used to differentiate various types of vasospastic diseases, asthma, and cardiac diseases
2 *Therapeutic*
   a To relieve vasospasm of upper extremity, head and face
   b To relieve "status asthmaticus"
   c To relieve angina and other forms of cardiac pain
   d To relieve hyperhidrosis of the upper extremity

Anatomy The stellate ganglion, a fusion of the inferior cervical and first thoracic ganglia, is a mass approximately 2×2×0 5 cms which lies behind the vertebral artery in the space between the transverse process of the 7th cervical vertebra and the neck of the first rib The apex of the right lung is in close relation to the ganglion on the right side but lies approximately 2 cm lower on the left and therefore is not so close The ganglion is in close relation to the junction of the subclavian artery, the inferior thyroid and the first intercostal artery The central branches of the ganglion arise from the 7th and 8th cervical nerves Peripheral connections are to the middle and superior cervical ganglia, cardiac plexus, cervical spinal nerves, to brain along vertebral arteries Small branches may pass to recurrent laryngeal and phrenic nerves

Materials Standard regional set containing 10 cm needles

Technique Posterior Approach

1 *Position*
   a Place the patient in the prone position on his side with pillow under head or
   b Allow the patient to sit up over the edge of an operating table leaning forward with arms folded or resting on an elevated stand The operator stands behind the patient
2 *Landmarks* Spine of 7th cervical vertebra and each vertebra above and below it
3 *Procedure*
   a Palpate and mark the site of the spine of the 7th cervical vertebra
   b Raise an intradermal wheal along the transverse process of the 7th cervical vertebra 4 5 cms from the midline
   c Introduce a 10 cm needle perpendicularly through the wheal following the median sagittal plane and establish contact with the

with the saggital plane of the body Direct it downward and medially towards the seventh cervical transverse process At a depth of 5 or 6 cms the tip of the transverse process of the 7th cervical or the neck of the first rib is encountered

3 Withdraw needle slightly when contact with bone is made and reinsert directing it downward and inward The needle is on the first rib Contact with the first rib must be made
4 Place needle once again on the neck of the first rib (or may it impinge upon the transverse process of the first dorsal vertebra)
5 Change position of hub of needle so that an angle of 80–90° is made with the saggital plane of the body
6 Advance needle 1 or 2 cms until it impinges upon bone The needle will be within the fascial plane of the stellate ganglion
7 Inject 5 cc of 1% procaine at this site

Thoracic Sympathetic Block

Definition Block of the sympathetic ganglia of the thoracic chain by paravertebral injection of local anesthetic drugs

Indications

Diagnostic To differentiate between disease of the sympathetic nervous system and related conditions

Therapeutic To relieve cardiac and other visceral pain

Anatomy The thoracic sympathetic ganglia lie along the body of the vertebrae approximately 3 cms below the transverse processes They are interconnected by a nervous chain which courses along the anterolateral surface of the vertebral bodies and loops over the heads of the ribs

Procedure Preparations and materials are essentially the same as for thoracic paravertebral block

1 Introduce the 10 cm needle and establish contact with the rib or transverse process of the desired vertebrae Start with the bevel pointed medially
2 Direct the needle in a caudad direction until the inferior border of the transverse process is located
3 Set marker at 4 cms on shaft of the needle
4 Incline the needle at an angle of 20° to median sagittal plane and almost perpendicular to the curvature of the back and advance it until it glances off the lower border of the vertebra
5 Introduce the needle for a distance of 3 cms The body of the vertebra is usually encountered at this depth if the angle is correct
6 Rotate the needle 180° and advance it another centimeter as long as it rests against bone
7 Inject 5 cc of 2% procaine for each ganglion blocked

3 Always perform block with an assistant and in an operating room equipped for resuscitation and other emergency measures

Comment

1 Withdraw needle and reinsert at a slightly different site if blood or spinal fluid is obtained
2 Allow 15 minutes to elapse after the procaine block if therapeutic block with alcohol is being performed
3 **Remember that stellate ganglion block is fraught with dangers and should be performed only by experienced individuals**

Technique Anterior Approach

1 *Position* Place the patient in the upright sitting position with his arms at his side The operator should face the patient
2 *Landmarks*
   a Midpoint of clavicle
   b Body of the seventh cervical vertebra
3 *Procedure*
   a Locate and mark midpoint of clavicle on the skin overlying it
   b Raise an intradermal wheal 1 cm medial to this mark and just above the upper border of the clavicle
   c Introduce an 8 or 10 cm needle through the wheal in a horizontal direction at level of clavicle Direct it posteriorly and medially at angle of 45° to skin for distance of 6 or 7 cms until the body of first thoracic vertebra or the junction of 1st thoracic and 7th cervical vertebrae is encountered
   d Inject 5 cc 2% or 10 cc 1% procaine at the vertebrae

Remarks Precautions, anesthesia, and other factors are same as described under directions for the posterior approach

Alternate Method—Anterior Approach*

Position of Patient

1 Recumbent supine with head turned to side opposite to the injection
2 Arm of side to be blocked at side
3 Depress shoulder caudad

Landmarks (a) Sixth cervical transverse process (b) Seventh cervical trans verse process This is identified by locating the 6th cervical first and measuring downwards 2 cms from that point (c) Midpoint of clavicle

Procedure

1 Raise a skin wheal 1 cm above the midpoint of the clavicle
2 Introduce an 8 cm needle through the skin wheal at an angle of 45°

* Technique of Volpitto and Ritsteen

Paravertebral Block—Lumbar Region

Definition A block of the spinal nerves of the lumbar region by paravertebral injection of a local anesthetic drug

Types

Diagnostic To determine the presence of vasospastic disease, or diseases of the sympathetic nervous system

Therapeutic To produce sympathetic block for diseases characterized by hyperactivity of the autonomic nervous system

Anesthetic For abdominal, urological or pelvic operations, used in conjunction with sacral block or paravertebral block of thoracic region

Anatomy The anterior primary divisions of the first four lumbar nerves form a series of oblique loops in the substance of the psoas muscle and thus give rise to the lumbar plexus The 12th thoracic and the 5th lumbar contribute to the plexus In the lumbar region, the spinal nerve lies cephalad to the transverse process of the corresponding vertebra The transverse processes of the lumbar vertebrae lie opposite the corresponding spinous processes A space 1 to 2 cms in width separates each spine in this region in the midline The transverse process is located by drawing a transverse line through the tip of the spinous process

Materials Standard regional set containing 10 cm needles

Technique

1 *Position* Arrange the patient lying on the side opposite to the side to be injected
2 *Landmarks*
   a Spine of the lumbar vertebrae
   b A line connecting the superior borders of the ilium crosses between the spinous processes of 4th and 5th lumbar vertebrae Often it may pass across the 4th spinous process
   c Transverse process of lumbar vertebrae
3 *Procedure*
   a Raise wheals 4 cms from the midline opposite the superior borders of the spinous processes of vertebrae selected
   b Set the marker at 4–5 cm on the shaft of a 10 cm needle
   c Introduce the needle perpendicularly through the wheal until the transverse process is encountered Usually the needle is introduced a depth of 4 to 5 cms before bone is encountered
   d Advance the marker 3 cms from the skin surface when bone is encountered
   e Partly withdraw the needle and reinsert it at an angle of 25° to the medial sagittal plane and at the same angle in a cephalad direction The needle glances off the edge of the superior border of the transverse process into the substance of the psoas muscle

Comment

1. The ganglia lie 3 cms below the transverse processes Incline the needle more medially if bone is not encountered at this depth and more vertically if bone is encountered before this depth is attained
2. Never attach the syringe to the needle in seeking the landmarks and ganglia

Alcohol Block of Sympathetic Ganglia

Principle Alcohol is injected into or about nerve tissue to destroy it by its sclerosing action The destruction of nerve tissue is similar to that obtained by sectioning a nerve and presents the following features

1. It is typical of Wallerian degeneration
2. Nerves regenerate after a variable period of time
3. Small unsheathed nerves may be permanently destroyed, large heavily sheathed nerves are only temporarily impaired
4. Fibrosis frequently occurs which predisposes to neuritis

Dose A single injection of 5 cc of absolute alcohol causes an area of necrosis in muscle 1 cm in diameter

Procedure

1. Perform block as described above Inject 2 cc of 2% procaine and note the extent and distribution of anesthesia
2. Allow ten minutes to elapse and inject an additional 3 cc of procaine into each needle This minimizes pain of alcohol injection
3. Inject 5 cc of absolute alcohol in half cc amounts attempting aspiration between each introduction
4. Introduce 0 25 cc procaine through each needle as it is withdrawn This washes the alcohol from its lumen
5. **Maintain patient on his side for an hour to minimize diffusion of the alcohol**

Comment	*Reasons*
1 Do not use excessive quantities of procaine	The alcohol is diluted and the sclerosing action diminished
2 Always employ absolute alcohol	Diluted alcohol is less effective as a sclerosing agent
3 Inject the alcohol slowly and preferably over a period of several minutes	The injection is painful, particularly if done rapidly
4 Attempt aspiration frequently during the injection	The needle may shift during an injection and a vital structure will be injured
5 Always wash the alcohol from the hollow of the needle with procaine solution before withdrawing it from the tissues	A sinus tract may form to the site of injection due to the sclerosing action of alcohol

Paravertebral Block—Lumbar Region

Definition A block of the spinal nerves of the lumbar region by paravertebral injection of a local anesthetic drug

Types

Diagnostic To determine the presence of vasospastic disease, or diseases of the sympathetic nervous system

Therapeutic To produce sympathetic block for diseases characterized by hyperactivity of the autonomic nervous system

Anesthetic For abdominal, urological or pelvic operations, used in conjunction with sacral block or paravertebral block of thoracic region

Anatomy The anterior primary divisions of the first four lumbar nerves form a series of oblique loops in the substance of the psoas muscle and thus give rise to the lumbar plexus The 12th thoracic and the 5th lumbar contribute to the plexus In the lumbar region, the spinal nerve lies cephalad to the transverse process of the corresponding vertebra The transverse processes of the lumbar vertebrae lie opposite the corresponding spinous processes A space 1 to 2 cms in width separates each spine in this region in the midline The transverse process is located by drawing a transverse line through the tip of the spinous process

Materials Standard regional set containing 10 cm needles

Technique

1 *Position* Arrange the patient lying on the side opposite to the side to be injected
2 *Landmarks*
   a Spine of the lumbar vertebrae
   b A line connecting the superior borders of the ilium crosses between the spinous processes of 4th and 5th lumbar vertebrae Often it may pass across the 4th spinous process
   c Transverse process of lumbar vertebrae
3 *Procedure*
   a Raise wheals 4 cms from the midline opposite the superior borders of the spinous processes of vertebrae selected
   b Set the marker at 4–5 cm on the shaft of a 10 cm needle
   c Introduce the needle perpendicularly through the wheal until the transverse process is encountered Usually the needle is introduced a depth of 4 to 5 cms before bone is encountered
   d Advance the marker 3 cms from the skin surface when bone is encountered
   e Partly withdraw the needle and reinsert it at an angle of 25° to the medial sagittal plane and at the same angle in a cephalad direction The needle glances off the edge of the superior border of the transverse process into the substance of the psoas muscle

f Advance it as far as the marker and inject 7–8 cc of 2% procaine solution after attempting aspiration in two planes

Anesthesia

1 *Onset* Within five minutes if procaine is employed and the needle is in close contact with the lumbar nerves
2 *Distribution* Along distribution of the plexus The ilio hypogastric, ilio inguinal, genitocrural, external femoral cutaneous, and other nerves involved in the lumbar plexus will be affected
3 *Duration* Usually one hour if procaine is employed

Complications

1 The needle may enter the subarachnoid space if it is inclined at an acute angle
2 The needle may be advanced too far inward and pierce a major vessel such as the vena cava, aorta, or enter an abdominal organ

Contra Indications

1 Local infections in the lumbar region

Comment The fifth lumbar nerve is best blocked by introducing the needle in a caudad and medial direction over the inferior border of the transverse process

PARAVERTEBRAL BLOCK OF SYMPATHETIC GANGLIA IN LUMBAR REGION

Definition Block of the sympathetic ganglia of the lumbar region by para vertebral injection of local anesthetic drugs

Indications

1 *Diagnostic* For temporary relief of certain forms of hypertension, vaso spastic disturbances of extremities and various diseases of the au tonomic nervous system
2 *Anesthetic* To permit manipulation of upper abdominal viscera

Anatomy The lumbar sympathetic ganglia lie along the anterolateral sur faces of the bodies of 4 lumbar vertebrae 3–4 cms below the transverse process

Technique The technique for sympathetic block in the lumbar region is simi lar to the paravertebral block except the needles are introduced at a different angle, and deeper into the tissues (Fig 135)

1 *Landmarks* Same as for lumbar paravertebral block
2 *Position* Same as for lumbar paravertebral block
3 *Procedure*
   a Raise intradermal wheals (over the transverse process) 3 cms from midline of the desired vertebrae

b Advance needle perpendicularly to skin and establish contact with transverse process of the vertebrae
c Partly withdraw the needle and incline it in a cephalad and medial direction so that it slides off the upper border of transverse process
d Continue to advance the needle in cephalad direction, for 2–3 cms or until body of vertebra is encountered
e Attempt aspiration and inject 10 to 15 cc of 1% procaine for each ganglion

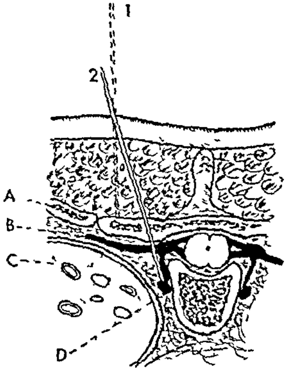


FIG 135 Method of inducing lumbar sympathetic block.

Anesthesia

1 *Onset* Almost immediately if the ganglia are encountered directly by the needle
2 *Distribution* No sensory anesthesia results unless the lumbar nerves are encountered Vasodilatation characterized by an increase of warmth, redness, and absence of sweating of the skin over the lower extremity is the most prominent change
3 *Duration* Undetermined The beneficial effects may last from one hour to several days depending upon the condition for which the block is performed

Complications

1 The needle may be advanced into the aorta, vena cava, renal vessels, pancreas, and other vital structures
2 The lumbar nerves may be pierced (these pass between each of the spaces between the transverse processes)

Comment Block is preferred if alcohol is to be used as the lumbar nerves are not affected by it

Transacral Block

Definition A paravertebral block produced by introducing a local anesthetic solution through the posterior sacral foramina The sacral nerves are anesthetized as they emerge from the sacral canal

Uses

1 *Anesthetic*
   a For the same purposes as caudal block Most frequently employed in cases in which caudal block is not possible because the caudal canal is not accessible
   b As an adjunct to caudal block for rectal surgery
2 *Therapeutic* For sciatica and other neuralgias involving sacral nerves

Anatomy See caudal block for description of sacrum and distribution of caudal nerves

Materials Standard regional set containing 10 cm , 8 cm and 5 cm needles

Technique

1 *Position* Place the patient in the prone position Place a pillow beneath the hips to elevate the sacrum
2 *Landmarks*
   a Posterior superior iliac spines
   b Cornua of the sacrum
3 *Procedure*
   a Palpate the posterior superior iliac spines and mark their location on the skin (Fig 136)
   b Raise an intradermal wheal one cm medial and caudad to each (Fig 136)
   c Palpate the sacral cornua and raise an intradermal wheal over each one (Fig 136)
   d Connect both wheals by a line (Fig 136)
   e Divide the line into three equal parts and raise a wheal at each point of division The second, third, fourth, and fifth sacral foramina will lie approximately under these wheals (Fig 136)
   f Raise an intradermal wheal 2 5 to 3 0 cms cephalad to and on the same line as the wheal designating the second sacral foramen The first sacral foramen is thus located
   g Introduce an 8 cm needle through the wheal (second sacral) perpendicular to the skin and advance until the posterior aspect of the sacrum is encountered

h Incline the needle one way or another, medially, caudad, cephalad, or laterally, until contact with bone is lost and needle enters the foramen

i Advance the needle 1 5 cm into the foramen (use markers) Inject 5 cc of 2% procaine at this site

j Repeat procedure for the first sacral foramen advancing the 10 cm needle 2 cms after contact with bone is lost Inject 6 cc of 2% procaine at this site

k Repeat procedure for 3rd sacral foramen Advance a 5 cm needle 1 cm after contact with bone is lost Inject 4 cc solution at this site

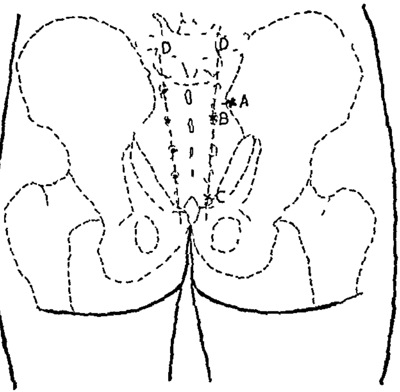


FIG 136 Landmarks for transacral block (A) Posterior superior iliac spines (B) Sacral foramina (C) Sacral cornua (D) 5th lumbar vertebrae

l Repeat the procedure for the fourth sacral foramen Advance a 5 cm needle 0 5 cm into the foramen

m Advance a 5 cm needle laterally to the sacral cornua and inject 2 cc of 2% procaine This anesthetizes the fifth sacral nerve as it emerges through the fifth sacral foramen

Anesthesia

1 *Onset* Immediately if procaine is employed
2 *Duration* One to two hours or more if procaine is employed
3 *Distribution* Approximately the same as for caudal block

Complications

1 The needle may pass inward to pelvis if advanced too far
2 The needle may pass into sacro iliac joint if directed too far laterally
3 The solution may be distributed to the posterior aspect of sacrum

Comments

1 Note that the sacrum varies in size and thickness
2 Note that the needle may advance into the foramen directly without encountering bone
3 Note that needles may be bent and develop hooklike points if gentle ness is not used when bone is encountered
4 Incline the needles *inward* rather than outward and in the same plane as the wheals
5 Always begin the block by injecting the second foramen Then pro ceed to the others
6 Block the second and third sacral nerves on both sides if caudal block is associated with transacral block

NERVE BLOCKS

Block of Cranial Nerves

The cranial nerves which are blocked are the fifth and its branches and, occasionally, the tenth or vagus

Gasserian Ganglion Block

Definition Anesthesia obtained by depositing a local anesthetic drug into the area surrounding the Gasserian ganglion (5th cranial nerve)

Types Although a number of techniques have been described, the one em ploying the Hartal route through the foramen ovale is the one described here

Indications

1 *Diagnostic* As a means of differentiation between trigeminal and glossopharyngeal neuralgia (the glossopharyngeal nerve supplies the sensory innervation to the posterior third of the tongue) Relief of pain indicates trigeminal neuralgia
2 *Therapeutic* For relief of neuralgia (tic douloureux) if surgery is con traindicated or not desired
3 *Anesthesia* For surgery of the face and jaw Supplemental field blocks, such as cervical plexus block, may also be necessary Rarely employed for this purpose

Anatomy The fifth cranial or trigeminal nerve arises from the pons It is composed of a sensory dorsal root which gives rise to the Gasserian ganglion and an anterior motor root The ganglion gives rise to three

heads The motor root passes beneath the ganglion and, after joining with the third expansion of the ganglion, passes through the foramen ovale as the mandibular nerve The ganglion lies at the posterior extremity of the foramen ovale, which is a canal approximately 1 cm long To reach the ganglion, the needle must pass through the foramen ovale The ganglion extends from the petrous portion of the temporal bone to the foramen ovale and lies on the pterygoid process The infratemporal plate lies anterior to the foramen The needle encounters the plate before being diverted towards the foramen

Materials

1 Standard regional set containing a 10 cm needle approximately 1 9 mm diam
2 One 2 cc syringe to aspirate and inject procaine

Technique

1 *Position* Place the patient in the supine position The operator should stand on side to be injected
2 *Landmarks*
   a Condyloid notch (articulation of condyloid process of mandible)
   b Midpoint of zygomatic notch on side to be injected
   c A point 3 cm lateral to angle of the mouth, at the level of the 2nd upper molar tooth on side to be injected
   d Pupil of eye (as patient looks directly forward) on side to be injected
3 *Procedure*
   a Place the index finger of the left hand in front of the tragus Palpate the condyloid process and notch as the patient opens and closes his mouth
   b Allow the finger to slip anteriorly from the condyloid process along the zygoma until the sigmoid notch of the mandible is palpated
   c Hold the finger in the notch, and with finger pointing upward bisect the fingernail, and mark this point on the skin over the zygomatic arch This point corresponds to the midpoint of the zygoma (A Fig 137)
   d Mark another point on the same level and 1 cm anterior to the one corresponding to the mid point of the zygoma (B, Fig 137)
   e Locate a point 3 cms from the angle of the mouth at the level of the 2nd upper molar tooth with the mouth of the patient closed (C Fig 137) Raise an intradermal wheal in the skin at this point
   f Project an imaginary line through the pupil of the eye and the skin wheal (X Fig 137) and another through the point 1 cm anterior to the mid point of the zygomatic arch (point in step d) (X Fig

137) and the skin wheal This locates two planes one which is almost vertical, one which is inclined at an angle, backwards and upwards

g Introduce the 10 cm needle through the wheal described in e and advance along a line formed by the intersection of these two planes until the infratemporal plate is encountered, a distance of approximately 5–6 cms (set recorder at 6 cms)

h Place the recorder 1 cm from the skin Withdraw needle to subcutaneous tissue and redirect along a line formed by the intersection of the plane passing through the pupil of the eye and the wheal C and the plane passing through the *mid point* of the zygomatic arch

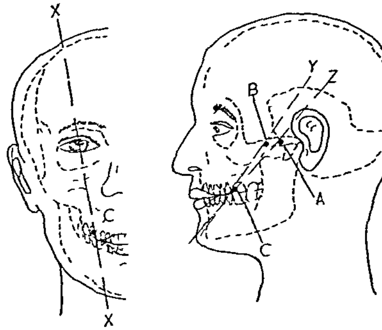


FIG 137 Landmarks for Gasserian ganglion block (see text)

(point in step a) and the wheal C (Z, Fig 137) The needle will enter the foramen ovale if guided in this direction Paresthesias are felt by the patient along the course of the mandibular nerve

i Inject 1 cc of a 2% procaine solution for anesthesia very slowly so that it literally enters drop by drop If alcohol is to be employed, inject 5 drops procaine and follow slowly by 1 cc alcohol

Anesthesia

1 *Onset* Within few minutes after the injection is completed Rapid injection gives rise to symptoms of increased intracranial pressure

2 *Distribution* This corresponds to the distribution of the trigeminal nerve The cornea, eyelid, face and other structures innervated by this nerve are anesthetized

3 *Duration* One or more hours When alcohol is used, it varies with the individual, but may last from 6 to 12 months

Complications

1 Penetration into the brain substance if the needle is advanced more than 1 cm into the foramen ovale
2 Arterial puncture The internal maxillary artery may be encountered and bleeding results
3 Paralysis and loss of sensation of the conjunctiva and cornea Causes keratitis
4 Hemorrhage of the cheek
5 Herpes about lip—this is usually transient
6 Paralysis of eye muscles—this is usually transient

Precautions

1 Always inject procaine slowly
2 Always employ the supine position and allow the patient to remain in bed for several hours after the procedure
3 Always attempt aspiration before injection of procaine or alcohol and withdraw needle if spinal fluid is aspirated

Contra Indications

1 Diffuse painful conditions of face
2 Infections in the site of injection
3 In cases of neuralgia in which mandibular or maxillary or combined mandibular and maxillary blocks have not been given a trial first

Remarks

1 If an alcohol block is desired, perform a procaine block first Repeat it in several days and follow it by alcohol
2 **Gasserian ganglion block is a hazardous, difficult procedure It should not be performed except in extreme cases and only by the initiated**

Block of Ophthalmic Nerve

Definition Block of branches of ophthalmic nerve

Indications

Diagnostic and Therapeutic rarely employed for these purposes
Anesthetic for enucleation of eyeball or other occular operations and operations on the sinuses

Anatomy The ophthalmic nerve is purely a sensory nerve which arises from the Gasserian ganglion The nerve passes forward, upward and laterally along the lateral wall of the cavernous sinus The nerve passes through the superior orbital fissure and divides into three branches *lachrymal, frontal* and *nasociliary* These subdivide into terminal branches

Types The ophthalmic nerve may be anesthetized by blocking its branches by two injections, a lateral orbital and medial orbital

Materials Standard regional set

Technique

1 *Position* Place the patient in the supine position
2 *Landmarks* Margin of the orbit
3 *Procedure*
Lateral orbital block
a Introduce a 5 cm needle a little above or below outer canthus at margin of orbit (A, Fig 138)
b Allow needle to penetrate along lateral wall for 3 5 cms Retract eyeball either up or down
c Inject 2–3 cc 2% procaine slowly at this site
Medial orbital block
a Introduce 5 cm needle at point 1 cm vertically above the caruncle (just below eyebrow)
b Insert needle for a distance of 3 cms along the upper medial angle of orbit close to its wall (A, Fig 138)
c Inject 2 cc 2% procaine slowly at this site

Anesthesia

Onset immediate if procaine is employed
Duration one hour if procaine is employed
Distribution The combined lateral and medial blocks produce anesthesia in the following areas Ethmoidal, sphenoidal and frontal sinuses, as well as nasal cavity, front and tip of nose, upper eyelid and conjunctiva, muscles of eye

Complications

1 Protrusion of eyeball
2 Injury to optic nerve

Comment The lower lid is supplied by infra orbital nerve and is not anesthetized

Block of Maxillary Nerve

Definition Block of second or maxillary division of the trigeminal nerve

Types

1 Oral route (employed by dentists)
2 Extra oral route
a Orbital route into foramen rotundum (not commonly employed)
b Zygomatic or extra oral route—simplest, quickest, safest

Indications

1 *Diagnostic* None
2 *Therapeutic* For neuralgia of second division of fifth cranial nerve

3 *Anesthetic* Operations on upper lip, antrum, hard and soft palate, upper jaw and tonsils

Anatomy The maxillary nerve runs forward from the semi lunar ganglion between the ophthalmic and mandibular nerves along lower border of the cavernous sinus and passes from the skull through the foramen rotundum, through the pterygopalatine fossa and enters the orbit as the infra orbital nerve It divides into the palpebral, nasal, and labial nerves

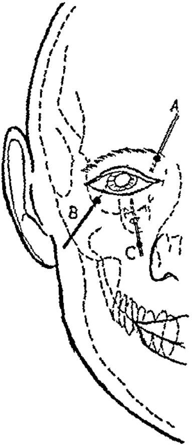


FIG 138 Landmarks for lateral and medial ophthalmic and infraorbital block

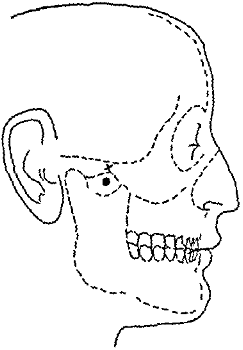


FIG 139 Landmarks for maxillary and mandibular nerve block The (X) indicates the midpoint of the notch, the dot, the point of entry of the needle

and infra orbital plexus En route to the pterygopalatine fossa it gives off the palatine and superior alveolar nerves

Materials Standard regional set

Technique *Zygomatic route*

1 *Position* Place the patient in the supine position with the head turned to one side and operator standing on the side to be injected
2 *Landmarks* The midpoint of the zygomatic notch
3 *Procedure* (Fig 139)
   a Raise an intradermal wheal at the midpoint of the zygomatic notch (Fig 139)

b Introduce an 8 cm needle perpendicularly to the skin surface so that it passes below the zygoma for a distance not to exceed 4 5 cm to 5 cm (use marker)
c Establish contact with the external pterygoid plate which is usually encountered at this depth
d Withdraw the marker and set it 1 cm from skin surface Reinsert the needle in a direction slightly anterior to the point of contact with bone Continue to introduce it until it slips off the anterior portion of the external pterygoid plate and advances as far as the marker
e Deposit 2 cc of 2% procaine solution after carefully attempting aspiration

Anesthesia

1 *Onset* Within five minutes after the injection, if procaine is employed
2 *Distribution* The cheek, lower eyelid, side of nose, upper lip, mucous membrane of nose, naso-pharynx, antra and ethmoid cells, soft and hard palate, and tonsils are usually involved
3 *Duration* One or more hours if procaine is employed

Complications

1 The needle may enter the orbit
2 The pterygoid plate may be overlooked if the needle is introduced too great a distance posteriorly
3 The pharynx may be entered if the needle is advanced more than 5 cm

Precautions Always use the marker to judge the required depth to advance the needle after the direction is changed

Contra Indications

1 Local infection at the site of injection
2 Distortions of the landmarks

Remarks The procaine block may be followed by an injection of 1 cc of absolute alcohol if therapeutic block is desired for neuralgia or other conditions necessitating prolonged anesthesia (see page 314)

Block of Mandibular Nerve

Definition Block of the third division of the trigeminal nerve

Types

1 Oral route
2 Extra oral route This is the more practical and the one usually employed

Indications

1 *Diagnostic* To differentiate glossopharyngeal from trigeminal neuralgia
2 *Therapeutic* For relief of trigeminal neuralgia, for relief of masseter spasm in cases of trismus
3 *Anesthetic* Operation on lower jaw, lower lip, and for extractions of the lower teeth

Anatomy The mandibular or inferior maxillary nerve is the third division of the trigeminal nerve The nerve is a combined sensory and motor It runs downward through the foramen ovale and divides into two branches, an anterior branch, which is small and chiefly motor, and a posterior branch which is larger and chiefly sensory The branches of the mandibular nerve are the auriculotemporal, lingual, buccinator, inferior alveolar and masseteric, anterior, middle and deep temporal, internal and external pterygoid

Materials Standard regional set

Technique Extra oral route

1 *Position* Place the patient in the supine position The operator should stand on side to be injected
2 *Landmarks* Same as for maxillary block
3 *Procedure* (Fig 139)
   a Follow the same procedure described for the maxillary nerve The only exception is that the needle is reintroduced to pass posterior to the external pterygoid plate of sphenoid bone for a distance of 0 5 cm at which point 1 to 2 cc of 2% procaine solution is injected

Anesthesia

1 *Onset* within 5 to 10 minutes
2 *Distribution* Temporal region, dura at base of skull, temporo mandibular articulation, auricle of ear, external auditory meatus, lower face and eye, mucous membrane of mouth, tongue, salivary glands, muscles of mastication, anterior belly of digastric, mylohyoid and tensor palatine and tympanic muscles
3 *Duration* One or more hours if procaine is employed

Complications

1 The needle may pass into the pharynx if it is introduced a distance greater than 0 5 cm beyond pterygoid plate
2 Severe bleeding may result if the internal maxillary artery is encountered

Precautions

1 Use a marker to avoid introducing needle too far
2 Partly withdraw needle after pterygoid plate is encountered and aim approximately 1 cm behind point of first contact with bone

Contra Indications

1 Infections about the face
2 Distortion of landmarks

Remarks The procaine block may be followed by 1 cc of absolute alcohol if therapeutic block is desired (see page 314)

BLOCKS OF PERIPHERAL NERVES

Brachial Plexus Block

Definition Brachial plexus block is a block designed to produce anesthesia of the arm and forearm It is accomplished by infiltration of the trunks, divisions, or cords of the plexus with a local anesthetic solution

Indications

1 *Anesthetic* For operations on the hand and forearm (particularly ten dons)
2 *Therapeutic* To produce sympathetic block of the hand and forearm

Types

1 *Supraclavicular* This is the most commonly employed approach be cause it is simplest, most successful, and utilizes the most reliable landmarks
2 *Infraclavicular* This approach is less frequently employed because the blood vessels in this region are parallel to the plexus and may be punc tured Often the needle is broken as it is inserted beneath the clavicle
3 *Axillary* This approach is not popular because the blood vessels in this region may be punctured In addition, the plexus fans out at this point and renders infiltration of all component parts difficult
4 *Paravertebral* This approach is very difficult to execute technically

Materials Standard regional set containing an 8 cm needle

The Supraclavicular Approach

Anatomy The brachial plexus is formed from the anterior primary divisions of the 5th, 6th, 7th cervical and 1st thoracic nerves These join to form an upper, a middle, and a lower trunk The trunks give rise to 6 divi sions which unite in various ways to form cords which in turn give rise to the nerves of the arm, forearm, and shoulder girdle The plexus possesses a fan like arrangement as it runs downward and outward from the vertebrae and converges so that the cords and nerves pass

closely together beneath the midpoint of the clavicle over the surface of the first rib

Technique

1 *Position*

a Place patient in the supine position Arrange the arm on the side to be injected in slight abduction, and rotate the head in the opposite direction The operator should stand on the side to be injected

2 *Landmarks*

a A point midway and 1 cm above the superior border of the clavicle The midpoint of the clavicle is obtained by bisecting the distance between the acromioclavicular and the sternoclavicular joints

b The lateral border of the subclavian artery above the clavicle

c The external jugular vein (rendered prominent by having the patient blow out his cheeks) The vein passes downward and medial to the midpoint of the clavicle

d Tubercle of the 6th cervical vertebra

3 *Procedure* (Fig 140)

a Raise an intradermal wheal at the point (B, Fig 140), 1 cm above the midpoint of clavicle (A, Fig 140)

b Identify, by palpation, the subclavian artery and external jugular vein (C, D, Fig 140)

c Grasp the needle, unattached to the syringe, in the right hand and introduce it through the wheal, exercising care to avoid the artery and vein

d Set the marker for 1 5 cms and advance the needle posteriorly, caudad, and medially until the first rib is encountered Do not advance the needle any farther than the marker if the rib is not encountered

e Withdraw the needle 2 or 3 mm after the rib is encountered so that it lies in the same plane as the brachial plexus, i e , superficial to the deep fascia of the neck

f Place a drop of anesthetic solution on the open end of the hub of needle and ask the patient to take a deep breath This is to determine whether or not the pleura has been pierced There should be no movement of the drop

g Inject 10 cc of 2% procaine solution Perform aspiration frequently during the injection

h Palpate and mark the tubercle of the transverse process of the 6th cervical vertebra by placing the left index finger upon it

i Withdraw the needle almost to the skin

j Push marker all the way back on the shaft of the needle and reinsert the needle deep to the sternocleidomastoid muscle for a distance of

Precautions

1. Use a marker to avoid introducing needle too far
2. Partly withdraw needle after pterygoid plate is encountered and aim approximately 1 cm behind point of first contact with bone

Contra Indications

1. Infections about the face
2. Distortion of landmarks

Remarks The procaine block may be followed by 1 cc of absolute alcohol if therapeutic block is desired (see page 314)

Blocks of Peripheral Nerves

Brachial Plexus Block

Definition Brachial plexus block is a block designed to produce anesthesia of the arm and forearm It is accomplished by infiltration of the trunks, divisions, or cords of the plexus with a local anesthetic solution

Indications

1. *Anesthetic* For operations on the hand and forearm (particularly tendons)
2. *Therapeutic* To produce sympathetic block of the hand and forearm

Types

1. *Supraclavicular* This is the most commonly employed approach because it is simplest, most successful, and utilizes the most reliable landmarks
2. *Infraclavicular* This approach is less frequently employed because the blood vessels in this region are parallel to the plexus and may be punctured Often the needle is broken as it is inserted beneath the clavicle
3. *Axillary* This approach is not popular because the blood vessels in this region may be punctured In addition, the plexus fans out at this point and renders infiltration of all component parts difficult
4. *Paravertebral* This approach is very difficult to execute technically

Materials Standard regional set containing an 8 cm needle

The Supraclavicular Approach

Anatomy The brachial plexus is formed from the anterior primary divisions of the 5th, 6th, 7th cervical and 1st thoracic nerves These join to form an upper, a middle, and a lower trunk The trunks give rise to 6 divisions which unite in various ways to form cords which in turn give rise to the nerves of the arm, forearm, and shoulder girdle The plexus possesses a fan like arrangement as it runs downward and outward from the vertebrae and converges so that the cords and nerves pass

2 Piercing the pleura Pneumothorax results
3 Intraspinal injection "High" spinal or segmental spinal anesthesia results

Precautions

1 Always locate and maintain palpating finger on the subclavian artery while the needle is being introduced
2 Always contact the first rib with the needle before injecting the drug
3 Always identify the external jugular vein before making the puncture
4 Always test for entrance of the needle in the pleural space
5 Never insert the needle beyond the marker when seeking the first rib
6 Always perform aspiration to determine whether or not the spinal canal has been entered
7 Withdraw the needle completely if blood is aspirated in the syringe and make pressure in the supraclavicular fossa before attempting the block again

Contra Indications

1 The presence of infection of the extremity or at the site of the block
2 The presence of tumor masses which may distort landmarks
3 In psychically unsuited patients and children
4 For operations which may last more than one hour

Comment

1 Withdraw the needle and reinsert it if an artery or other blood vessel is entered
2 Seek paresthesias when inserting the needle The patient feels paresthesias radiating up and down the arm
3 Motor anesthesia is rarely complete in the large muscles Paresis is usually present, however

Brachial Plexus Block (Alternate Method)*

Procedure

1 Arrange patient and prepare materials in the same manner for technique described above
2 Locate junction of middle and inner third of clavicle and mark skin over clavicle
3 Raise an intradermal wheal 2 cms above this point
4 Raise a second intradermal wheal between the first wheal and the clavicle
5 Raise a third wheal 1 1/2 to 2 cms above the first wheal
6 Introduce an 8 cm needle through the first wheal and establish contact with the first rib

* Technique first suggested by Ralph T Knight.

approximately 6 cm towards the tubercle Allow the index finger of the left hand to remain over the tubercle during the injection

k. Aspirate to determine the presence of spinal fluid or blood and inject 5 cc of 2% procaine in this region

l Withdraw needle almost to the skin and introduce it again in a lateral caudad direction, inclined to such an angle so as to be directed behind the clavicle and anterior to the first rib

m Inject 5 cc of 2% procaine solution behind clavicle after performing aspiration

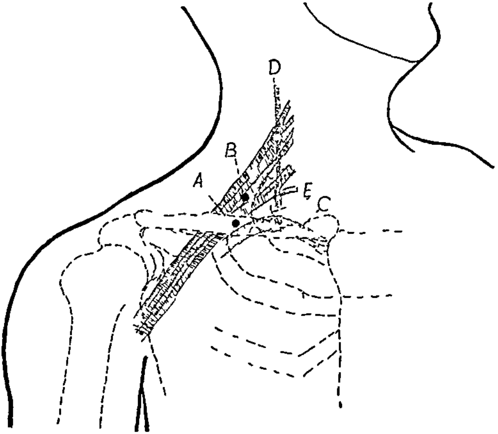


FIG 140 Landmarks for brachial plexus block by the supraclavicular route (A) Midpoint of the clavicle (B) Site of injection (C) Subclavian artery (D) External jugular vein (E) First rib

Anesthesia

1 *Onset* Ten to fifteen minutes
2 *Distribution* Complete in the hands, fingers, and forearm A zone of hypesthesia exists over the shoulder No anesthesia exists in the axilla
3 *Duration* One hour or more when procaine is employed

Complications

1 Piercing of blood vessels The subclavian artery or vein, external jugular vein and the superficial or deep transverse cervical artery are all liable to puncture

3 *Procedure*

a Place an applicator moistened with iodine or ink in the cubital fossa

b Flex the forearm up on the arm to make an angle of 90° and trace

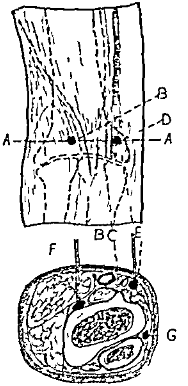


Fig 141 Landmarks for median and radial nerve block at the elbow (A) Line above crease of elbow (B) Tendon of biceps (C) Brachial artery (D) Vein (E) Median nerve (F) Radial nerve beneath brachioradialis muscle (G) Ulnar nerve

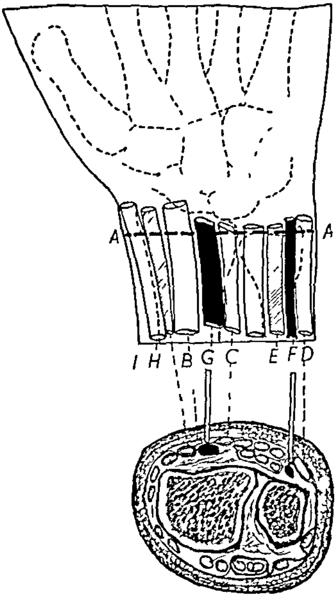


Fig 142 Landmarks for median and radial nerve block at the wrist. (A) Transverse line through ulnar styloid for determining point of injection (B) Flexor carpi radialis longus tendon (C) Palmaris longus tendon (D) Flexor carpi ulnaris tendon (E) Ulnar artery (F) Ulnar nerve (G) Median nerve (H) Radial artery

or mark junction of skin of arm and forearm with the moistened applicator A transverse line results (A, Fig 141)

c Locate the tendon of the biceps (felt by flexing and extending forearm with hand in supination) (B, Fig 141)

d Locate the brachial artery (C, Fig 141) by palpation and raise an intradermal wheal medial to it (D, Fig 141)

7 Introduce 8 cm needles through the other two wheals parallel to the first needle and contact the first rib in a similar fashion
8 Inject 10 cc 2% procaine into each needle in the same manner described above Slightly withdraw the needle after 3 cc have been injected over the rib and inject the remainder over the plexus

REFERENCE

Labat, G Regional Anesthesia 2nd Ed Pp 215–235 W B Saunders Co, Philadelphia 1930

Median Nerve Block

Definition Anesthesia produced by blocking the median nerve at its most superficial points

Types

1 Block at the elbow
2 Block at the wrist

Indications

1 *Anesthetic* For operations upon the arm and forearm in which brachial plexus block is not feasible
2 *Therapeutic* For vasospastic and other diseases involving the autonomic nervous system

Anatomy The median nerve arises from the medial cord of the brachial plexus and passes through the axilla along with the brachial artery It lies lateral to the artery until the elbow is neared It then crosses over to the inner aspect of the arm It then passes through the cubital fossa beneath the bicipital fascia and enters the forearm In the cubital fossa, it lies between the internal condyle of the humerus and the tendon of the biceps muscle The brachial artery lies between the tendon and the nerve At the wrist, the nerve becomes superficial and lies beneath the deep fascia, between the palmaris longus and flexor carpi radialis tendons

Materials Standard regional set

Median Block at the Elbow

Technique

1 *Landmarks*
   a Brachial artery
   b Tendon of biceps
   c Internal condyle of humerus
2 *Position of patient* Supine with the arm abducted and forearm extended

3 *Procedure*

a Place an applicator moistened with iodine or ink in the cubital fossa

b Flex the forearm up on the arm to make an angle of 90° and trace

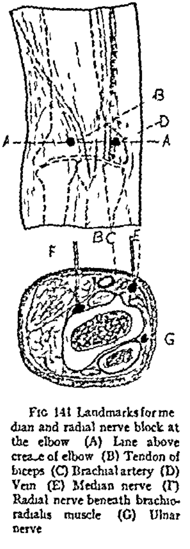


FIG 141 Landmarks for median and radial nerve block at the elbow (A) Line above crease of elbow (B) Tendon of biceps (C) Brachial artery (D) Vein (E) Median nerve (F) Radial nerve beneath brachioradialis muscle (G) Ulnar nerve

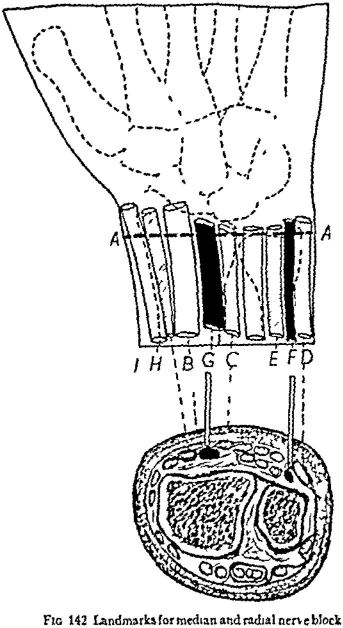


FIG 142 Landmarks for median and radial nerve block at the wrist. (A) Transverse line through ulnar styloid for determining point of injection (B) Flexor carpi radialis longus tendon (C) Palmaris longus tendon (D) Flexor carpi ulnaris tendon (E) Ulnar artery (F) Ulnar nerve (G) Median nerve (H) Radial artery

or mark junction of skin of arm and forearm with the moistened applicator A transverse line results (A, Fig 141)

c Locate the tendon of the biceps (felt by flexing and extending forearm with hand in supination) (B, Fig 141)

d Locate the brachial artery (C, Fig 141) by palpation and raise an intradermal wheal medial to it (D, Fig 141)

e Introduce a 5 cm needle through the wheal perpendicular to the skin through the superficial and deep fascia and seek paresthesias
f Attach the syringe to the needle and inject 3 cc of 2% procaine at this site
g Inject 2 or 3 cc in fanwise manner over the path of nerve
h Circumscribe a "garter" intracutaneously and subcutaneously with 1/2% procaine above the site of injection

Median Block at the Wrist

Technique

1 *Landmarks*
 a Tendons of palmaris longus and flexor carpi radialis muscles
 b Styloid process of the ulna
2 *Position* Place the patient in a supine position with the arm on a board and the palm facing upward
3 *Procedure*
 a Locate and mark a cross on the anterior aspect of the wrist through the styloid of the ulna (A, Fig 142)
 b Locate and mark the outline of the palmaris longus and flexor carpi radialis tendons (B, C, Fig 142)
 c Raise an intradermal wheal between the two tendons on transverse line through the styloid of the ulna
 d Introduce a 5 cm needle perpendicular to the skin through the superficial and deep fascia and advance it 0 5 cm beyond the deep fascia
 e Inject 2 cc 2% procaine at this site
 f Partly withdraw and incline the needle towards the flexor carpi radialis tendon Introduce needle deep to tendon and inject 2 cc of 2% procaine at this site
 g Massage the area to cause diffusion of solution into the tissues

Anesthesia

Onset Usually within 5 minutes if procaine is employed
Duration One hour

Comment

1 The median nerve lies beneath the flexor carpi radialis tendon in many instances The needle must be inclined in that direction to seek it
2 The transverse line marked in the cubital fossa does not correspond to and is above the line drawn through the condyles of the humerus
3 Median nerve blocks are best employed in conjunction with ulnar and radial nerve blocks

Note An intracutaneous and subcutaneous band (garter) of 1% solution of

procaine should be infiltrated about the entire arm when a combination of blocks is used to block any overlapping nerve fibres

Radial Nerve Block

Definition Anesthesia produced by block of the radial nerve where it is most superficial

Types

1 Block at the elbow (lateral)
2 Block at elbow (anterior) This is the most commonly employed type
3 Block at the wrist

Block at the Elbow

Indications

Anesthetic For surgery of hand or wrist
Diagnostic and Therapeutic Same as for median nerve

Anatomy The posterior cord of the brachial plexus gives rise to two divisions, one large and one small The larger gives rise to the radial nerve, the smaller the axillary The radial nerve passes behind the axillary artery at the anterior surface of the latissimus dorsi muscle across the teres major and proceeds downward posteriorly and laterally into the musculospiral groove between the long and medial heads of the triceps muscle. It then passes towards the lateral side of the arm At approximately 10 cms above the external condyle it crosses the humerus in an anterior direction between the brachioradialis and brachialis muscles after having pierced the lateral intermuscular septum As it reaches the external condyle of the humerus, it divides into two branches, the radial and the interosseous

Materials Standard regional set

Technique (Fig 142)

1 *Landmarks* Same as for median nerve block
2 *Position* Same as for median nerve block
3 *Procedure*
   a Raise an intradermal wheal 1 cm lateral to the tendon of biceps on a line of bend of elbow as located in the same manner as for the median nerve block
   b Introduce a 5 cm needle through the wheal perpendicular to the skin
   c Place the index finger of left hand at the posterior aspect of the lateral condyle of humerus
   d Advance needle in the direction of the finger until bone is encountered Seek paresthesias at this site and inject 5 cc 2% procaine at this site

REFERENCE

Labat, G Regional Anesthesia 2nd Ed Pp 237–246 W B Saunders Co, Philadelphia 1930

Ulnar Nerve Block

Definition Anesthesia of the ulnar nerve produced by blocking it at its most superficial points along its course

Uses

Anesthetic Same as for median and radial nerve blocks
Diagnostic Same as for median and radial nerve blocks

Types

1 Block at the elbow
2 Block at the wrist

Anatomy The ulnar nerve arises from the medial cord of the brachial plexus, passes downward in the arm and becomes superficial between the internal condyle of the humerus and the olecranon process of the ulna The nerve may be palpated in the groove thus formed It then courses between the heads of the flexor carpi ulnaris muscle and downward to the wrist where it becomes superficial It then lies on the outer border of the tendon of the flexor carpi ulnaris before it courses into the hand to supply the skin and muscles there

FIG 143 Landmarks for ulnar block at the elbow (see text)

Materials Standard regional set

Block at the Elbow

Technique (Fig 143)

1 *Landmarks* The groove between the internal condyle of the humerus and the olecranon process
2 *Position*
   a Place the patient in the lateral prone position on the side opposite the one to be injected
   b Allow the arm to rest alongside body
3 *Procedure*
   a Palpate and grasp the nerve above the groove using thumb and index finger of left hand
   b Raise an intradermal wheal on the tip of the fold of skin thus grasped The wheal should be 3 cms above the bony prominence as shown in Fig 143

c Introduce a 5 cm needle in the direction of nerve and nearly parallel to it for a distance of several centimeters
d As soon as paresthesias are felt inject 5 cc 2% procaine

Anesthesia

Onset Usually within 5 minutes if procaine is employed
Duration One hour if procaine is employed

Block at the Wrist

Technique

1 *Landmarks*
 a Styloid process of ulna (same transverse line as for median block) (A, Fig 143)
 b Tendon of the flexor carpi ulnaris muscle
2 *Position* Place the patient in the supine position with the hand in supination
3 *Procedure* (Fig 143)
 a Palpate the tendon of the flexor carpi ulnaris at the level of styloid of the ulna (D, Fig 142, p 419)
 b Raise an intradermal wheal on the radial side of the tendon of flexor carpi ulnaris on the line through the ulnar styloid
 c Introduce a 5 cm needle perpendicular to the skin and pierce the deep fascia
 d Seek paresthesias and when these are felt inject 3 cc 2% procaine solution at this site

Comment Avoid injection into the tendons, the joint or directly into the nerve

REFERENCE

Labat G Regional Anesthesia 2nd Ed Pp 246–248 W B Saunders Co, Philadelphia 1930

Block at the Thumb and Fingers

Technique

1 *Landmarks* Metacarpal bones (Fig 144)
2 *Position* Place the patient in the supine position Dorsum of hand should face upward
3 *Procedure*
 a Raise an intradermal wheal on each side of the midpoint of the metacarpal bone of the digit to be anesthetized or all the digits if desired (A, B, Fig 144)

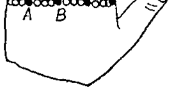


Fig 144 Block of the digits (see text)

b Advance a 5 cm needle towards palm perpendicular to the skin Inject 1% procaine as the needle is advanced
c Infiltrate along the area from the wheal to web of finger on either side

Comment Place a finger on the palm and palpate for the needle so that it does not perforate skin of palm

Block of Digits

Technique

1 *Landmarks* Phalanx proximal to site of operation
2 *Position* Dorsum of the finger to be anesthetized should face upward

Procedure

1 Raise an intradermal wheal on the dorsum of the digit over the phalanx
2 Inject 1% procaine through the skin to bone on one side
3 Almost completely withdraw and insert the needle on the other side in same manner as in step 2

Comment

1 Do not add vasoconstrictor drugs to the procaine (avoid gangrene)
2 Do not use tourniquet for digital operation when regional anesthesia is induced
3 Inject drug slowly

REFERENCES

Adams, R C Regional Anesthesia for Operations About the Neck and Upper Extremity Anesthesiology, *2* 515, September, 1941
Labat, G Regional Anesthesia 2nd Ed P 336 W B Saunders Co , Philadelphia, 1930

Block of Intercostal Nerves

Definition Block of the intercostal nerves as they course the intercostal grooves
Uses Rib section, thoracic and upper abdominal operations
Anatomy The intercostal nerve accompanies the intercostal artery and vein in the intercostal groove along the inferior border of the rib The nerve is inferior to the artery The vein is superior to both nerve and artery

Technique (Fig 145)

1 *Landmarks*
a Midaxillary line
b Inferior border of the rib
2 *Position* Sitting upright The patient's hands should be folded over his head to allow ample exposure of the thorax

3 *Procedure*

a Raise an intradermal wheal over the lower border of the desired rib in midaxillary line

b Introduce a 5 cm needle through the wheal until contact is made with the lower border of the rib (A, Fig 145)

c Retract the skin and soft tissues in the region of the puncture downward with the thumb of the right hand (B, Fig 145)

d Insert the needle 1/4 to 1/2 cms beyond the lower border of the rib Paresthesias may result if the needle encounters the nerve

e Inject 5 cc 2% procaine at this site

f Infiltrate the skin and subcutaneous tissue in the midaxillary line with 1% procaine to block superficial nerve filaments

Anesthesia

1 *Onset* Within 5 to 10 minutes when procaine is employed

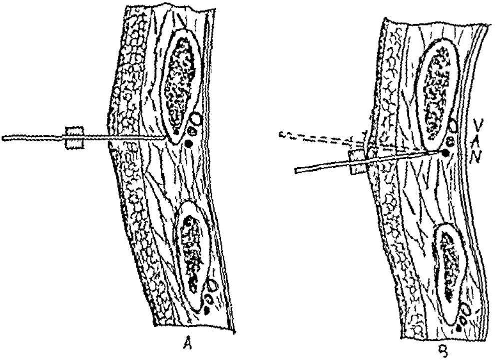


Fig 145 Block of the intercostal nerves (see text)

2 *Distribution* Along course of nerve distal to the site of injection

3 *Duration* One hour

Comment Always attempt aspiration Vessels or pleura may be entered

REFERENCE

Bartlett, R W Bilateral Intercostal Nerve Block Surgery, *71* 194–197, August, 1940

Femoral Nerve Block

Definition Block of femoral nerve below the inguinal ligament

Uses For operations on the anteromedial aspect of the thigh

Anatomy The femoral nerve arises from the lumbar plexus, and emerges be-

neath the inguinal ligament lateral to the femoral artery and vein to lie beneath the deep fascia of the thigh

Technique (Fig 146)

1 *Landmarks*
 a Inguinal ligament
 b Femoral artery
2 *Position* Supine
3 *Procedure*
 a Identify the inguinal ligament (A, Fig 146)
 b Palpate the femoral artery with left index finger and retract it medially during injection
 c Raise an intradermal wheal just below the Poupart's ligament lateral to artery (B, Fig 146)
 d Introduce an 8 cm needle through the wheal perpendicular to the skin until the iliac fascia has been pierced
 e Adjust the marker for one centimeter as soon as needle has passed the fascia and insert it 1 cm beyond the fascia Attempt to elicit paresthesias
 f Fix the needle when paresthesias are elicited and inject 5 cc 2% procaine at this site If no paresthesias are elicited, inject 25 cc of the procaine solution in a fanwise direction beneath the fascia and into the muscle

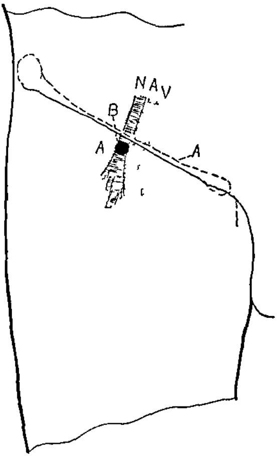


Fig 146 Landmarks for block of the femoral nerve (see text)

Anesthesia

Onset Usually within 5 minutes if procaine is employed
Distribution Medial and anterior aspect of thigh

REFERENCE

Labat, G Regional Anesthesia 2nd Ed P 480 W B Saunders Co , Philadelphia, 1930

Femoral Cutaneous Nerve Block

Definition Block of the external femoral cutaneous nerve at inguinal region

Uses For superficial operations upon the lateral aspect of the thigh (skin grafts, removal of tumors, etc)

Anatomy The external femoral cutaneous nerve arises from the lumbar

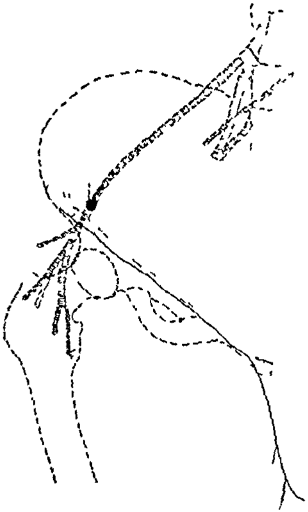


Fig 147 Landmarks for block of the femoral cutaneous nerve (see text)

plexus, traverses the iliac fossa and emerges beneath the inguinal ligament to pass into the thigh

Technique

1 *Landmarks*
   a The anterior superior iliac spine
   b The inguinal ligament
2 *Position* Supine
3 *Procedure*
   a Raise an intradermal wheal 1 cm caudad and medial to the anterior superior iliac spine (Fig 147)

neath the inguinal ligament lateral to the femoral artery and vein to lie beneath the deep fascia of the thigh

Technique (Fig 146)

1 *Landmarks*
   a Inguinal ligament
   b Femoral artery
2 *Position* Supine
3 *Procedure*
   a Identify the inguinal ligament (A, Fig 146)
   b Palpate the femoral artery with left index finger and retract it medially during injection
   c Raise an intradermal wheal just below the Poupart's ligament lateral to artery (B, Fig 146)
   d Introduce an 8 cm needle through the wheal perpendicular to the skin until the iliac fascia has been pierced
   e Adjust the marker for one centimeter as soon as needle has passed the fascia and insert it 1 cm beyond the fascia Attempt to elicit paresthesias
   f Fix the needle when paresthesias are elicited and inject 5 cc 2% procaine at this site If no paresthesias are elicited, inject 25 cc of the procaine solution in a fanwise direction beneath the fascia and into the muscle

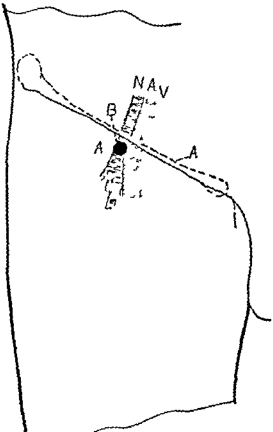


Fig 146 Landmarks for block of the femoral nerve (see text)

Anesthesia

Onset Usually within 5 minutes if procaine is employed
Distribution Medial and anterior aspect of thigh

REFERENCE

Labat G Regional Anesthesia 2nd Ed P 480 W B Saunders Co Philadelphia, 1930

Femoral Cutaneous Nerve Block

Definition Block of the external femoral cutaneous nerve at inguinal region

Uses For superficial operations upon the lateral aspect of the thigh (skin grafts removal of tumors, etc)

Anatomy The external femoral cutaneous nerve arises from the lumbar

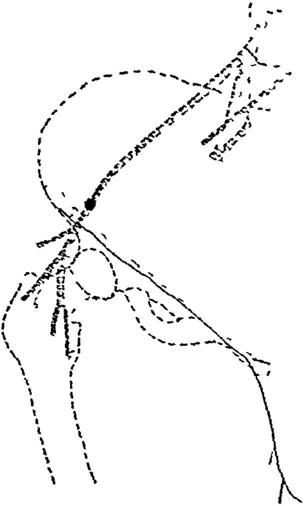


FIG. 147 Landmarks for block of the femoral cutaneous nerve (see text)

plexus traverses the iliac fossa and emerges beneath the inguinal ligament to pass into the thigh

Technique

1 *Landmarks*
   a The anterior superior iliac spine
   b The inguinal ligament
2 *Position* Supine
3 *Procedure*
   a Raise an intradermal wheal 1 cm caudad and medial to the anterior superior iliac spine (Fig 147)

neath the inguinal ligament lateral to the femoral artery and vein *to lie beneath the deep fascia of the thigh*

Technique (Fig 146)

1 *Landmarks*
  a Inguinal ligament
  b Femoral artery
2 *Position* Supine
3 *Procedure*
  a Identify the inguinal ligament (A, Fig 146)
  b Palpate the femoral artery with left index finger and retract it medially during injection
  c Raise an intradermal wheal just below the Poupart's ligament lateral to artery (*B, Fig 146*)
  d Introduce an 8 cm needle through the wheal perpendicular to the skin until the iliac fascia has been pierced
  e *Adjust the marker for one* centimeter as soon as needle has passed the fascia and insert it 1 cm beyond the fascia *Attempt* to elicit paresthesias
  f Fix the needle when paresthesias are elicited and inject 5 cc 2% procaine at this site If no paresthesias are elicited, inject *25 cc of* the procaine solution in a fanwise direction beneath the fascia and into the muscle

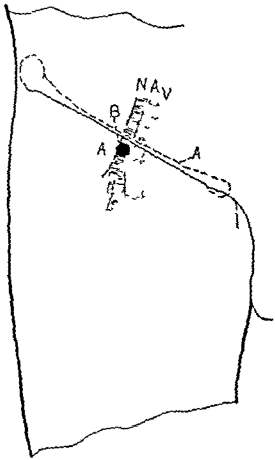


Fig 146 Landmarks for block of the femoral nerve (see text)

Anesthesia

Onset Usually within 5 minutes if procaine is employed
Distribution Medial and anterior aspect of thigh

REFERENCE

Labat, G Regional Anesthesia 2nd Ed P 480 W B Saunders Co, Philadelphia, 1930

Femoral Cutaneous Nerve Block

Definition Block of the external femoral cutaneous nerve at inguinal region

Uses For superficial operations upon the lateral aspect of the thigh (skin grafts, removal of tumors, etc)

Anatomy The external femoral cutaneous nerve arises from the lumbar

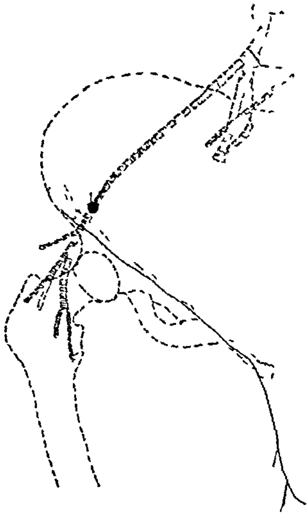


Fig 147 Landmarks for block of the femoral cutaneous nerve (see text)

plexus, traverses the iliac fossa and emerges beneath the inguinal ligament to pass into the thigh

Technique

1 *Landmarks*
   a The anterior superior iliac spine
   b The inguinal ligament
2 *Position* Supine
3 *Procedure*
   a Raise an intradermal wheal 1 cm caudad and medial to the anterior superior iliac spine (Fig 147)

b Introduce an 8 cm needle vertically through the wheal and advance it until the iliac bone is encountered
c Inject 1% procaine while needle is advancing and 10 cc after the needle encounters the bone
d Partially withdraw the needle and perform fanlike injections in lateral and medial direction over an area of 4 or 5 cms along the spine

Anesthesia

1 *Onset* Usually within 5 minutes if procaine is used
2 *Distribution* Anterolateral aspect of the thigh

REFERENCE

Labat, G Regional Anesthesia 2nd Ed P 480 W B Saunders Co , Philadelphia, 1930

Sciatic Nerve Block

Definition Sciatic block is block of the greater sciatic nerve secured by injecting a local anesthetic drug at the point of exit from the pelvis
Types The type which employs the lateral approach on thigh is the commonly employed route

Indication

1 *Anesthesia* For fractures and operations on the foot and lateral aspect of the leg
2 *Therapeutic* Neuralgias (sciatica)

Anatomy The sciatic nerve arises from the lumbar plexus (L_4, L_5, S_1, S_2, S_3) and passes from the pelvis between the pyriformis muscle by way of the great sciatic notch It turns downward between the great trochanter and the tuberosity of the ischium and becomes superficial at the lower border of the gluteus maximus muscle It then courses down the posterior aspect of the leg to the popliteal fossa where it divides into the tibial and common peroneal nerves Branches are given off to the muscles of the posterior aspect of the thigh on its descent

Materials Standard regional set containing a 10 cm needle

Technique

1 *Position* Arrange the patient so that he lies on his side with the affected side *upward* and the thigh is flexed to form an angle of 135–150° with the trunk The operator stands so that *he faces the back* of the patient
2 *Landmarks*
a Posterior superior iliac spine
b Great trochanter of the femur

3 *Procedure*

a Palpate the greater trochanter and mark a point on the overlying skin

b Palpate the posterior superior iliac spine and mark the point on the overlying skin

c Draw a line (ilio trochanteric) between the two points (A, B, Fig 148)

d Determine the midpoint of the ilio trochanteric line and draw a line perpendicular to it in a caudad direction for a distance of 3 cms and raise a wheal at its end (C, Fig 148)

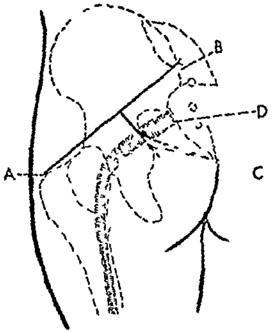


Fig 148 Landmarks for block of the sciatic nerve (see text)

e Arrange the marker for 6–7 cms on the 10 cm needle and introduce it perpendicularly to the skin through the wheal

f Seek paresthesias and inject 10 cc of 2% procaine slowly

Anesthesia

1 *Onset* Usually appears within 10 minutes if procaine is employed
2 *Distribution* Posterior thigh, leg and foot
3 *Duration* 1–1 1/2 hours

Complications Shock and other circulatory phenomena from trauma to nerve

Precautions

1 Do not inject alcohol into the sciatic nerve (motor paralysis may result)

2 Withdraw the needle 1 cm if bone is encountered and inject the solution

Contra-Indications None

Remarks This particular block is little employed

REFERENCE

Labat, G Regional Anesthesia 2nd Ed Pp 326–332 W B Saunders Co, Philadelphia, 1930

Block of the Great Toe

Uses For operations involving the large toe if the operative area extends as far as its base

Technique (Fig 149)

1 *Landmarks*
   a Metatarsal bone of the great toe
   b Web between great and second toe

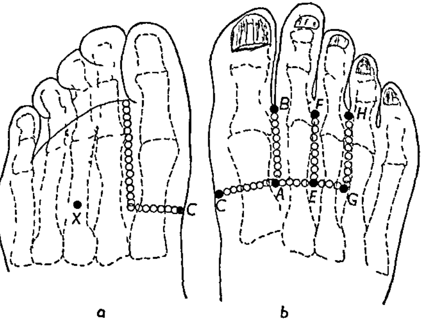


Fig 149 Landmarks for block of the toes

2 *Position* Supine with the sole of the foot in the left hand and dorsum facing upward

3 *Procedure*
   a Raise intradermal wheals at the
      (1) Dorsomedial border of foot alongside the metatarsal bone (C, Fig 149)
      (2) Web of the great toe (B, Fig 149)
      (3) Border of metatarsal of the great toe (A, Fig 149)

b Advance an 8 cm needle attached to a syringe containing 0 5% procaine through the wheal (A) in a direction normal to the skin
c Change the direction of needle to an oblique one when the skin has been pierced and inject 0 5% procaine in the interosseous space
d Repeat the injection in a fanwise manner along interosseous space (keep the hand beneath the sole to feel the needle as it advances forward)
e Introduce the needle into wheal over the web (B, Fig 149) and repeat fanwise injections as above
f Introduce the needle through the wheal at the border of the foot and inject in direction beneath the metatarsal and also over it towards the midline of the foot (C, A, Fig 149)

Comment

1 Do not employ more than 50 cc of 0 5% procaine to complete the block
2 Do not add vasoconstrictor drugs to the procaine solution in performing the block (it may cause gangrene)
3 Do not pierce the sole of the foot with needle at any time

REFERENCE

Labat G Regional Anesthesia 2nd Ed P 487 W B Saunders Co, Philadelphia 1930

Block of the Toes

Description Anesthesia of toes produced by infiltration of the intermetatarsal spaces

Uses Amputation and plastic operations of toes

Technique

1 *Landmarks*
 a Webs adjacent to the selected toe or toes
 b Proximal extremities of intermetatarsal space of toe or toes selected
2 *Position* Same as for great toe
3 *Procedure*
 a Raise four intradermal wheals, one at each web on either side of the toe (B, F, H, Fig 149) and one at the extremity of each intertarsal space on either side of the toe (A, E, G, Fig 149)
 b Insert the 10 cm needle through the proximal wheals and perform fanwise injections using 0 5% procaine (same as for great toe)
 c Incline the needle towards the median sagittal plane of the metatarsal bone and inject 2 or 3 cc of half per cent procaine on plantar surface of the metatarsal bone (X, Fig 149) This should be done through both distal wheals
 d Repeat injections through the distal wheals in the same manner as the proximal

Comment

1 Block as many toes as desired, all in the same manner
2 Inject each interosseous space if more than one toe is blocked
3 Do not pierce the sole of the foot with the needle Perform all injections on the dorsum

REFERENCE

Labat, G Regional Anesthesia 2nd Ed Pp 485–487 W B Saunders Co , Philadelphia, 1930

FIELD BLOCKS

Block of Scalp

Definition Field block of scalp
Uses For operations about the head, scalp, or for intra cranial surgery
Anatomy The scalp is innervated by the cervical plexus through the lesser and greater occipital nerves and through the trigeminal by the frontal,

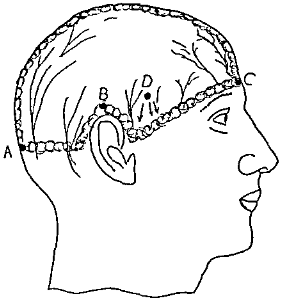


Fig 150 Landmarks for field block of the scalp

supratrochlear, supraorbital, auriculotemporal, temporomalar branches
These nerves pass into the subfascial region at a line which may be described as circling the head above the ear and passing through the glabella and the occiput Eventually the nerves become subcutaneous at the vertex as they pass through the various layers of the scalp

Technique

1 *Landmarks*
a The glabella
b The occiput

2 *Position* Place the patient in a sitting or supine position

3 *Procedure*

a Raise an intradermal wheal at a point over the glabella, and at a point one or two centimeters above the ear Raise a similar wheal at a point at the occiput (A, B, C, Fig 150)

b Infiltrate intracutaneously, subcutaneously, and subperiosteally through the wheal over the ear and continuing the infiltration in a line to a point anterior to the ear at the level of the meatus (Fig 150)

c Repeat a similar line of infiltration posterior to the ear at the level of the meatus

d Continue the lines of infiltration to the occiput posteriorly and to the glabella anteriorly raising intracutaneous wheals to make a continuous line around the head

e Raise wheals and infiltrate along the midline of the scalp from the glabella to the occiput Perform the injections in the subcutaneous, intracutaneous, and periosteal layers

f At a point anterior to and 3 or 4 cm above upper border of ear raise a wheal and pass the 8 cm needle downward toward zygomatic arch into the temporal fossa close to the bone to anesthetize the deep temporal nerves Deposit 10-25 cc 1/2% procaine at this site (D, Fig 150)

Comment

1 Use a fine needle for intracutaneous wheals and 5 or 8 cm needle for deep injections

2 Do not use more than 200 cc of 1/2% procaine for the entire block

3 Use epinephrine to minimize absorption in this highly vascular area

REFERENCE

Mousel, L H Anesthesia for Operations About the Head and Neck Anesthesiology, *2* 61-73, January, 1941

Local Block of Prepuce

Materials Standard regional set

Uses For operations on foreskin of penis (circumcision)

1 Rinse penis with soap and water, sterilize skin with non irritating dis infectant and drape field with towels

2 Raise an intradermal wheal on the dorsum of the penis behind the corona

3 Establish a line of wheals with 1% procaine behind the corona, to encircle prepuce Raise each succeeding wheal from the preceding one to make sure the entire procedure is painless (Fig 151)

4 Retract the foreskin from the corona and raise a line of submucosal wheals in a similar manner as the intradermal wheal
5 Inject a half cc of 1% procaine on either side of the frenulum to complete the block If the block is not satisfactory, it is because this part was not properly injected

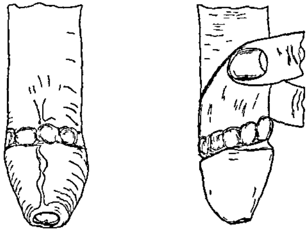


FIG 151 Landmarks for block of the prepuce

LOCAL BLOCK OF TONSILS

Uses To anesthetize peritonsillar tissues for tonsillectomy

Materials

1 1% procaine containing epinephrine 1 10,000
2 10% cocaine
3 One tongue depressor
4 Light and head mirror
5 Long curved needle and syringe
6 Curved grasping forceps
7 Emesis basin

Position of Patient Sitting upright with head cocked backward in a rest

Landmarks

1 Upper and lower pole of tonsil (Fig 152)
2 Border of anterior and posterior pillar

Procedure

1 Depress the tongue and paint the fauces with an applicator soaked with 10% cocaine solution squeezed dry
2 Select three points, one at the upper, one at the middle, and one at the lower border of the anterior pillar and a point at the upper posterior pillar Inject 1/2 cc procaine at each one very slowly
3 Grasp the tonsil with the curved forceps, draw it gently towards the

midline Inject procaine behind the tonsil to infiltrate its bed and capsule Use a sufficient quantity to saturate the bed and encircle the tonsil (2 or 3 cc)

4 Allow several minutes to elapse for establishment of anesthesia

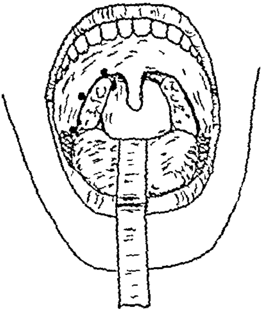


Fig 152 Block of the tonsil

REFERENCE

Mousel, L H Regional Anesthesia for Operations About the Head and Neck Anesthesiology, 2 61-73, January, 1941

Abdominal Field Block

Definition Block of ends and branches of thoracic spinal nerves as they pass through the abdominal wall

Uses For abdominal operations Block allows use of median *or paramedian* incision for either upper or lower abdominal surgery

Technique

1 *Landmarks*
   a Xyphoid of sternum
   b Costal margin
   c Lateral border of rectus muscle
2 *Position* Place the patient in the supine position
3 *Procedure* (Fig 153)
   a Raise intradermal wheals at the tip of the xyphoid, along the costal margin at 10th costal cartilage and at the lateral border of the rectus at the level of the umbilicus
   b Attach a 5 or 8 cm needle, whichever appears most suitable to the

syringe and commence injection at lowermost wheal by passing needle through the superficial fascia

c Incline the needle towards the rectus muscle and pierce the fascia of the muscle A feeling of break of resistance is noted when the fascia is entered

d Advance the needle 0 5 to 1 cm depending upon whether or not

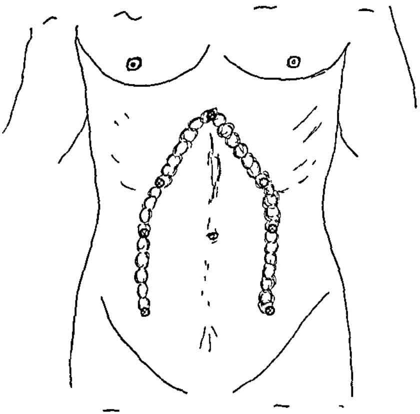


Fig 153 Abdominal field block

the patient is lean or obese and inject 2 cc 0 5% procaine into the area

e Withdraw the needle almost to the skin and reintroduce it in a fan wise manner a number of times both in a caudad and a cephalad direction, injecting procaine in a similar amount into the muscle each time (Fig 153)

f Withdraw and repeat injections also in a fanwise manner through the remaining wheals along the costal margin

g Infiltrate subcutaneous tissues in such a manner that all wheals are connected and make a continuous line from the xyphoid to the last intradermal wheal

Comment

1 Perform either a unilateral or bilateral block

2 Prolong the block downward along the entire rectus muscle by raising

other wheals at the lateral border of the rectus below the level of umbilicus as far as the pubis, if lower abdominal surgery is necessary

Field Block of Inguinal Region

Definition Block of the 11th and 12th thoracic, ilio inguinal, and iliohypogastric nerves as they pass into the inguinal region

Uses For inguinal hernioplasty and operations in the inguinal region

Technique

1 *Landmarks*
  a The anterior superior iliac spine
  b The pubic spine
  c The inguinal ligament
  d The spermatic cord
  e The internal and external inguinal rings
2 *Position* Supine with operator standing on side to be injected
3 *Procedure*
  a Raise an intradermal wheal 2 5 cms above and medial to the anterior superior iliac spine (A, Fig 154)
  b Introduce a 10 cm needle (or 8 cm for thin subjects) connected to 10 cc syringe filled with 1% procaine and pass through the skin and subcutaneous tissues to transversalis fascia Inject several cc of procaine at this site
  c Withdraw the needle and perform similar injections in a fanwise manner through the same wheal along a line which extends from the anterior superior iliac spine almost to the umbilicus (A, B, Fig 154)
  d Infiltrate subcutaneously along the same line A total of approximately 50 cc of solution is required for this part of the block
  e Raise an intradermal wheal directly over the pubic spine (C, Fig 154)
  f Introduce the 8 cm needle and inject 8–10 cc of solution in fanwise direction in the deep tissues along the ramus of the pubis Inject on each side of the spermatic cord and into edge of the rectus muscle towards the midline (Arrows, Fig 154)
  g Infiltrate the subcutaneous tissues along the ramus of the pubis
  h Grasp the spermatic cord at the level of the external ring and introduce the needle through the pubic wheal in an upward direction into the cord Inject 5 cc 1% procaine at this site
  i Palpate the internal inguinal ring Direct the needle with syringe attached through the pubic wheal subcutaneously in a direction medial to the margin of the ring
  j Pierce the fascia medially, laterally, and above the ring with a needle and inject 3 cc each time This blocks the genitocrural nerve

k Raise an intradermal wheal in the skin at the midpoint and immediately below the inguinal ligament and lateral to the femoral artery (D, Fig 154)

l Inject 8–10 cc of 2% procaine into the deep tissues along the upper border of the inguinal ligament in a fanwise manner

m Repeat the infiltration into the subcutaneous tissues along inguinal ligament This blocks the overlapping nerves from the thigh

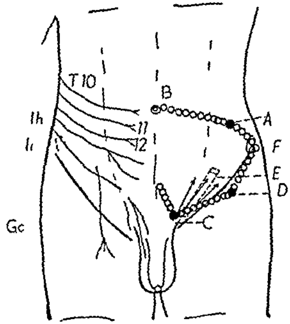


FIG 154 Inguinal field block (Ii) Ilio-inguinal nerve (Ih) Iliohypogastric nerve (Gc) Genitocrural nerve Arrows indicate lines of infiltration along the cord E (See text)

Comment

1 Do not inject the internal ring when irreducible hernia is present
2 Do not cause trauma to the cord by multiple punctures
3 Avoid piercing the femoral vessels in performing infiltration through the pubic wheal

REFERENCE

Labat G Regional Anesthesia 2nd Ed P 436 W B Saunders Co Philadelphia, 1930

FIELD BLOCK OF PERINEUM

Definition Anesthesia of anterior half of the female perineum by perineal nerve block and infiltration along the vulva

Uses For operations on the female perineum

Anatomy The perineal nerve is the larger and inferior of the two terminal branches of the pudendal nerve It passes along the lateral wall of the

ischio rectal fossa and divides into labial and muscular branches which supply the perineum

Technique

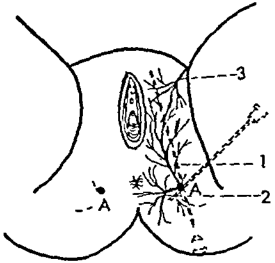
1 *Landmarks* Tuberosity of the ischium (A, Fig 155)

2 *Position* Lithotomy

3 *Procedure*

a Palpate, mark off a point and raise an intradermal wheal over and slightly medial to the tuberosity of the ischium (B, Fig 155)

Fig 155 Field block of the perineum 1 The skin wheal is raised medial to the ischial tuberosity (A) and the needle is introduced normal to the skin to block the perineal branch of the pudendal (1) Shows the inferior hemorrhoidal branch of the pudendal and the direction of the needle for blocking it 3 Shows the cutaneous branches of the ilio inguinal and the direction of the needle for blocking it All three injections are made through one wheal



b Advance an 8 cm needle perpendicularly through the skin for a distance of 2 5 cms and inject 8 cc of 2% procaine at this site

c Infiltrate both the deep and subcutaneous tissues along the margin of the anterior portion of the vulva This blocks the ilio inguinal and genito femoral nerve filaments which overlap the perineal nerve in the anterior pubic region (C, Fig 155)

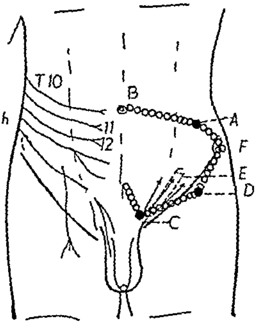
REFERENCE

Labat G Regional Anesthesia 2nd Ed Pp 452–474 W B Saunders Co Philadelphia 1930

k Raise an intradermal wheal in the skin at the midpoint and immediately below the inguinal ligament and lateral to the femoral artery (D, Fig 154)

l Inject 8–10 cc of 2% procaine into the deep tissues along the upper border of the inguinal ligament in a fanwise manner

m Repeat the infiltration into the subcutaneous tissues along inguinal ligament This blocks the overlapping nerves from the thigh



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Uses For operations on the female perineum

Anatomy The perineal nerve is the larger and inferior of the two terminal branches of the pudendal nerve It passes along the lateral wall of the

i Fetal hemoglobin has higher affinity for oxygen than adult
j The larynx is placed higher and more anterior and not completely developed
k Laryngeal spasm develops more easily and may be quickly followed by cardiac arrest
l The pattern of respiration varies considerably Characterized by gasping, sobbing, inspiratory or expiratory pauses, cog wheel effect or breath holding
m Lungs easily ruptured during positive pressure breathing

4 *Gastrointestinal System*

a Secrete saliva easily and obstruct airway
b Swallow air causing stomach to dilate and hinder respiratory movements Use a catheter to deflate
c Gastric retention frequent in emergency surgery

5 *Metabolic Functions*

a Renal function not fully developed until 6 months of age Lack concentrating power
b Acid base balance fluctuates easily with vomiting, diarrhea or dehydration
c Liver function not fully developed
d Metabolic rate rises during first year of life to 50 calories per square meter per hour and then gradually declines in later years reaching normal at 15 years

6 *Skeletal System*

a Bones not fully developed—easily injured
b Soft parts and skin easily traumatized

7 *Effects of Prematurity*

a Unable to maintain body temperature at normal limits
b Respiratory centers not developed fully Respiration is irregular—cyanosis may develop periodically Oxygen restores pattern
c Susceptible to infections
d Head not calcified and sutures not closed
e Response to depressant drugs may be profound
f Ventilating surface may not be fully developed and adequate

Utility of Various Anesthetic Drugs for Pediatric Anesthesia

Drugs All the drugs ordinarily used for adults may be used for pediatric anesthesia The following variations are noted in behavior from adults

PART VII

SPECIALIZED PROCEDURES

PEDIATRIC ANESTHESIA

The technique of anesthesia for pediatric patients must be modified from that used for adults because of differences in size and physiological development Some of the factors which make pediatric anesthesia different from adult are as follows

1 *Nervous System*

a Psychic trauma occurs more frequently and is more of a problem
b Effects of analgesic, anesthetic, hypnotic and narcotic drugs upon various centers are more variable
c Convulsions, hyperthermia and other abnormal responses occur more frequently in children
d Temperature control not normal (falls in newborn)

2 *Circulatory System*

a The pulse rate is much faster 120–200 first year, 80–150 second year, 70–130 third year
b The blood pressure is more variable, labile and difficult to estimate
c The blood volume is 10% of body weight (same as adult) but blood loss more significant 0 1 cc loss=18 cc loss in adult, 30 cc loss=550 cc loss in adult
d Cardiac output is greater than in adult At birth almost 100%
e Sinus arrhythmia may be common and is normal in infants and children

3 *Respiratory System*

a The susceptibility to anoxia and CO excess differs and is probably greater than in the adult
b The respiratory rate is faster, tidal exchange smaller
c Functional residual air volume is smaller in comparison to total lung volume
d Respiratory muscles are not fully developed
e Chest wall is thin and soft and undeveloped
f Air passages are small and easily obstructed
g More lymphoid tissue is present in nasal and oropharynx giving rise to obstruction Breathing may be entirely through the mouth
h The pressure in the pulmonary artery (newborn) is same as the systemic pressure

I *Avertin*—Behavior same as in adults, but response and duration of action more variable

1 Larger doses required 80–120 mgm /kilo
2 Readily expelled due to inability to cooperate
3 More difficult to administer to children Failures more frequent because of difficulties

Uses

1 As basal narcotic for *non painful* diagnostic procedures
2 A premedicating agent in unruly subjects followed by ether, cyclopropane, etc

J *Ultra short acting Barbiturates*

1 Response more variable than in adults
2 Difficult to administer intravenously because venipuncture not easily performed
3 Respiratory depression and spasm are vexing and hazardous complications of more serious consequence

Uses

1 As a basal narcotic for non painful diagnostic procedures or in conjunction with nitrous oxide, ether, etc
2 To control convulsions

K *Muscle Relaxants*—usually not necessary because relaxation is obtained with general anesthesia with ease Tissues are soft and non resilient When used the following objections are noted

1 Apnea necessitates need for controlled respiration which is undesired
2 Venipuncture not easily performed
3 Lethal dose not known—may be given inadvertently

Uses Drug most commonly employed is succinyl choline

1 To facilitate intubation
2 To relax muscles in large children

L *Regional Anesthesia*—children are not psychically suited for regional anesthesia Only satisfactory in newborns and infants when employed by skillful surgeon and anesthetist

1 Procaine is the drug of choice because of its low toxicity
2 Dilute concentrations $\frac{1}{2}$% should be employed
3 Total dose should not exceed 0 1 gram per 15 lbs of body weight

Techniques for Pediatric Anesthesia

A Open Drop

Procedure Same as for adults with following modifications

1 Use oxygen by nasal catheter under the mask at 1 liter per minute
2 Do not wrap towels around the mask (Fig 156)

A *Cyclopropane*—behavior is same as in adults

1 Respiration depressed and apnea results easily
2 Possibility of overdosage more easily overlooked by novices
3 Laryngeal spasm may occur, particularly in changing over to ether
4 An even plane of anesthesia not maintained as easily as in adults
5 Closed system is necessary and is not always available or practical

B *Nitrous Oxide*

1 Resistance to drug varies from child to child Surgical anesthesia not secured with ease without anoxia
2 Relaxation poor

Uses

1 In combination with trichlorethylene or vinyl ether for anesthesia for minor surgical procedures or ethyl ether for major procedures
2 In combination with basal narcosis (avertin, or ultra short-acting barbiturates)

C *Ethylene*—more potent than nitrous oxide, but used in the same manner and for same purposes

D *Ether*—general response is same as in adults with following exceptions The most widely used and safest of all anesthetic agents for pediatrics

1 Tachycardia is more frequent due to sympathetic stimulation
2 Mucous secretion is more prevelant and troublesome
3 Exaggerated breathing is more pronounced than in adults
4 Acidosis a greater factor than in adults

E *Vinyl Ether*—behavior in general same as adults except that

1 Convulsions occur more frequently
2 Secretions may be more abundant and prominent

F *Chloroform*—behavior same as in adults Not used for either adults or children

G *Ethyl Chloride*—same objections as for adults—namely it is cardiotoxic

1 Opisthotonos and muscle spasm common
2 May cause rapid respiration (vagal effect)

H *Trichlorethylene*—behavior same for children as for adults

Uses

1 As an analgesic mixed with air oxygen or nitrous oxide
2 To fortify nitrous oxide in the semi closed apparatus for minor procedures

I *Avertin*—Behavior same as in adults, but response and duration of action more variable

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2 Dilute concentrations ½% should be employed
3 Total dose should not exceed 0 1 gram per 15 lbs of body weight

Techniques for Pediatric Anesthesia

A *Open Drop*

Procedure Same as for adults with following modifications

1 Use oxygen by nasal catheter under the mask at 1 liter per minute
2 Do not wrap towels around the mask (Fig 156)

A *Cyclopropane*—behavior is same as in adults

1 Respiration depressed and apnea results easily
2 Possibility of overdosage more easily overlooked by novices
3 Laryngeal spasm may occur, particularly in changing over to ether
4 An even plane of anesthesia not maintained as easily as in adults
5 Closed system is necessary and is not always available or practical

B *Nitrous Oxide*

1 Resistance to drug varies from child to child Surgical anesthesia not secured with ease without anoxia
2 Relaxation poor

Uses

1 In combination with trichlorethylene or vinyl ether for anesthesia for minor surgical procedures or ethyl ether for major procedures
2 In combination with basal narcosis (avertin, or ultra short acting barbiturates)

C *Ethylene*—more potent than nitrous oxide, but used in the same manner and for same purposes

D *Ether*—general response is same as in adults with following exceptions The most widely used and safest of all anesthetic agents for pediatrics

1 Tachycardia is more frequent due to sympathetic stimulation
2 Mucous secretion is more prevelant and troublesome
3 Exaggerated breathing is more pronounced than in adults
4 Acidosis a greater factor than in adults

E *Vinyl Ether*—behavior in general same as adults except that

1 Convulsions occur more frequently
2 Secretions may be more abundant and prominent

F *Chloroform*—behavior same as in adults Not used for either adults or children

G *Ethyl Chloride*—same objections as for adults—namely it is cardiotoxic

1 Opisthotonos and muscle spasm common
2 May cause rapid respiration (vagal effect)

H *Trichlorethylene*—behavior same for children as for adults

Uses

1 As an analgesic mixed with air oxygen or nitrous oxide
2 To fortify nitrous oxide in the semi closed apparatus for minor procedures

I *Avertin*—Behavior same as in adults, but response and duration of action more variable

1 Larger doses required 80–120 mgm /kilo
2 Readily expelled due to inability to cooperate
3 More difficult to administer to children Failures more frequent because of difficulties

Uses

1 As basal narcotic for *non painful* diagnostic procedures
2 A premedicating agent in unruly subjects followed by ether, cyclopropane, etc

J *Ultra short acting Barbiturates*

1 Response more variable than in adults
2 Difficult to administer intravenously because venipuncture not easily performed
3 Respiratory depression and spasm are vexing and hazardous complications of more serious consequence

Uses

1 As a basal narcotic for non painful diagnostic procedures or in conjunction with nitrous oxide, ether etc
2 To control convulsions

K *Muscle Relaxants*—usually not necessary because relaxation is obtained with general anesthesia with ease Tissues are soft and non resilient When used the following objections are noted

1 Apnea necessitates need for controlled respiration which is undesired
2 Venipuncture not easily performed
3 Lethal dose not known—may be given inadvertently

Uses Drug most commonly employed is succinyl choline

1 To facilitate intubation
2 To relax muscles in large children

L *Regional Anesthesia*—children are not psychically suited for regional anesthesia Only satisfactory in newborns and infants when employed by skillful surgeon and anesthetist

1 Procaine is the drug of choice because of its low toxicity
2 Dilute concentrations ½% should be employed
3 Total dose should not exceed 0 1 gram per 15 lbs of body weight

Techniques for Pediatric Anesthesia

A *Open Drop*

Procedure Same as for adults with following modifications

1 Use oxygen by nasal catheter under the mask at 1 liter per minute
2 Do not wrap towels around the mask (Fig 156)

3 Always use premedication of anticholinergic drug to avoid secretions

Uses For ether, vinyl ether, ethyl chloride or chloroform (not advised)

Objections

1 Oxygen tension in inhaled air not sufficient for adequate oxygenation
2 Secretions are more prevalent than in adults
3 Uneven level of anesthesia
4 Positive pressure and assisted respiration not possible

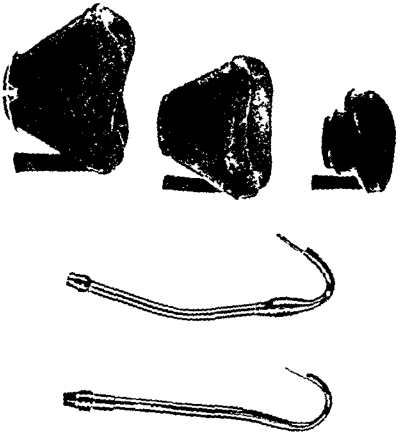


FIG 156 (A) Infant size mask used for pediatric anesthesia (B) Ether hooks used for insufflation techniques

5 Fire hazard exists with flamable agents
6 Coughing, breathholding and irritation from high concentration of irritating vapors
7 CO_2 elimination may be inadequate
8 Cold vapors are inhaled

Advantages

1 Simple apparatus
2 Minimal or no dead space
3 Permits use of volatile liquids These are more potent than gases

B *Insufflation*

Uses Most often used for ether, but may be used for nitrous oxide, ethylene or cyclopropane

Procedure Same as for adults except that Ayre's arrangement intratracheally is most practical, particularly for head and neck or oral surgery (page 196)

1 Anesthetize patient with open drop ether preceded by vinyl ether
2 Intubate and connect apparatus to insufflator and supply agent in quantity necessary to maintain anesthesia

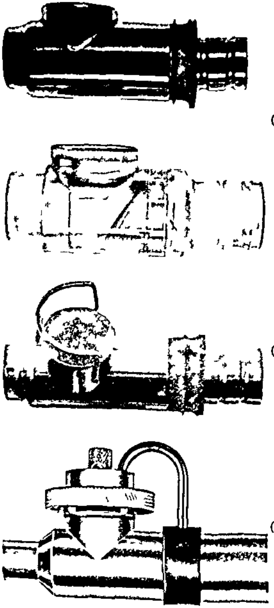


FIG 157 Non rebreathing valves commonly used for anesthesia for infants and children (a) Digby Leigh valve (top) and Stephen Slater valve (bottom) (b) Stephen Slater valve with drape guard (c) Fink valve

C *Semi Closed Method*

Principle The valves designed by Leigh and modified by Stephen, Slater, Fink and others reduce rebreathing to a minimum Only the gases contained between the valve and the mask are inhaled During intratracheal anesthesia the gas in the connector to the valve is inhaled The minute volume exchange of the patient must be supplied to the apparatus (Fig 157)

Standard adult type semi closed inhalers are not suitable because they permit excessive rebreathing

Procedure (*Leigh valve*)

1 Anesthetize patient with open drop ether and intubate
2 Connect apparatus to tube (Fig 158)

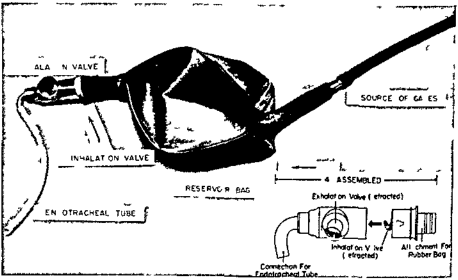


FIG 158 Non rebreathing valve assembled to breathing bag and delivery tube and endotracheal catheter A continuous flow of gases and vapors flow into the inhaler at the minute volume exchange of the patient Anesthesia is induced by the open mask technique The patient is intubated and the apparatuses then connected (Courtesy C R Stephen Elements of Pediatric Anesthesia Springfield Thomas 1954)

3 Commence flow of nitrous oxide with 20% or more oxygen
4 Fortify with ether or trichlorethylene or vinyl ether The gas is bubbled through the liquid
5 Assist or control respiration by placing thumb over exhalation valve and compressing breathing bag during inspiration and release on expiration

Advantages

1 Resistance is minimal
2 Rebreathing is minimal
3 Assisted and controlled respiration possible

Disadvantages

1 Large volume of gas used
2 Reservoir (bag) deflates readily and gases are lost
3 Endotracheal tube must be used for successful anesthesia
4 Positive pressure, controlled respiration and assisted breathing awkward and not easily controlled (require both hands)

Closed Systems

This, as in the case of adults, is the ideal technique if resistance, dead space, and sustained positive pressure can be eliminated

A To and Fro (McQuiston) (Fig 159)

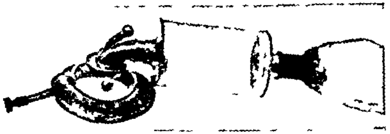


FIG 159 To and fro absorption unit for anesthesia for infants and children

Principle The to and fro inhaler is abbreviated so that the canister is approximately 4×8 cms , the mask is reduced in size and the breathing bag is smaller

Procedure Used in exactly same manner as to and fro for adults

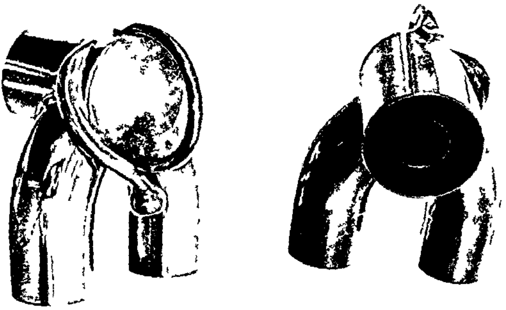
Disadvantages

1 Dead space excessive Extends to screen in mask Tends to extend as canister becomes exhausted
2 Efficiency of absorber varies as tidal volume varies Air space in canister must approximate tidal volume for adequate efficiency
3 Soda lime dust may be inhaled
4 Excessive warming due to proximity of canister to face
5 Addition of vapors such as ether not easily controlled
6 Tight leak proof system difficult to obtain

Circle Filter

The adult circle filter is unsatisfactory for pediatric use because of the following features

1 The breathing bag is too large and stiff Excessive sustained pressure is created in the inhaler Excursions of bag are too small to be seen or felt by the hand
2 Dead space in the chimney piece is excessive



(a) (b)

FIG 161 The Y chimney piece has been modified to eliminate all the dead space so that the only gases which are rebreathed are in the mask or connectors to the endotracheal tubes This is accomplished by having the gases enter the mask through the inner tube and leave in the outer tube The nipple (a) is used to connect the bypass bulb with the bag

4 Tubes	Large size eliminates resistance due to corrugations Thickness prevents collapse on inspirations and eliminates rebreathing from this source
5 Exhalation valve	Permits conversion to a semi closed inhaler if desired
6 Size of apperture on chimney piece	Permits use of standard size masks and intratracheal tube adapters and slip joints

Advantages

1 Reduces amount of apparatus required for anesthesia to the interchangeable parts
2 Permits use of any agent or combination of agents used for adults
3 Permits use of semi closed technique without CO_2 accumulation and without supplying volume flow on demand
4 Permits use of controlled respiration when indicated
5 Permits rapid induction

Disadvantages

1 Tube and chimney piece heavy and awkward

2 Bag cannot be closed off—gas lost when mask is lifted from face
3 Awkward for intratracheal use in head and neck surgery

Use of Modified Adult Circle Filler

Procedure The basic principles of anesthesia for adults is followed except during induction the hand bulb is used to circulate the gases and ventilate the mask The absorber is always turned on

A *Ethylene or Nitrous Oxide*

1 A flow of nitrous oxide or ethylene 80% oxygen 20% is passed into the inhaler at the minute volume exchange of the subject with the exhalation valve open enough to permit excess to escape

B *Ethylene or Nitrous Oxide Ether Oxygen Sequence*

1 Commence as in (1) above When patient is in Stage III gradually and slowly add ether using hand pump to facilitate mixing
2 Gradually reduce flow of nitrous oxide and increase ether as rapidly as possible without coughing or irritation
3 Reduce oxygen to metabolic flow and close the exhalation valve and shut off ether for several moments
4 Gradually resume ether again, increase rapidly as tolerated Use hand pump to circulate gas

C *Cyclopropane Oxygen*

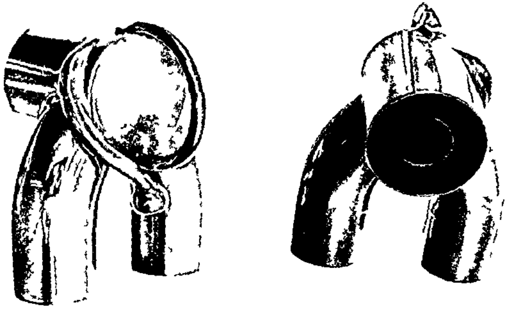
1 Apply mask and add sufficient oxygen to prevent patients breathing on empty bag
2 Turn on cyclopropane and oxygen to give a 10%-60% mixture at a rate 200–300 cc per minute or faster for larger patients
3 Work hand pump to facilitate rapid mixing
4 Reduce oxygen to metabolic needs and shut off cyclopropane when bag is filled
5 Add cyclopropane at 50 to 200 cc flows at required intervals to meet needs of patient

D *Cyclopropane Ether*

1 Induce anesthesia as in C When third stage has been attained continue addition of cyclopropane along with ether until patient tolerates ether without aid of cyclopropane

Comment

2 Circle filters with abbreviated connectors, bags and valves are avail



(a) (b)

FIG 161 The Y chimney piece has been modified to eliminate all the dead space so that the only gases which are rebreathed are in the mask or connectors to the endotracheal tubes This is accomplished by having the gases enter the mask through the inner tube and leave in the outer tube The nipple (a) is used to connect the bypass bulb with the bag

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2 Permits use of any agent or combination of agents used for adults
3 Permits use of semi closed technique without CO_2 accumulation and without supplying volume flow on demand
4 Permits use of controlled respiration when indicated
5 Permits rapid induction

Disadvantages

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3 Awkward for intratracheal use in head and neck surgery

Use of Modified Adult Circle Filter

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3 Reduce oxygen to metabolic flow and close the exhalation valve and shut off ether for several moments
4 Gradually resume ether again, increase rapidly as tolerated Use hand pump to circulate gas

C *Cyclopropane Oxygen*

1 Apply mask, and add sufficient oxygen to prevent patients breathing on empty bag
2 Turn on cyclopropane and oxygen to give a 40%-60% mixture at a rate 200-300 cc per minute or faster for larger patients
3 Work hand pump to facilitate rapid mixing
4 Reduce oxygen to metabolic needs and shut off cyclopropane when bag is filled
5 Add cyclopropane at 50 to 200 cc flows at required intervals to meet needs of patient

D *Cyclopropane Ether*

1 Induce anesthesia as in C When third stage has been attained continue addition of cyclopropane along with ether until patient tolerates ether without aid of cyclopropane

Comment

2 Circle filters with abbreviated connectors, bags and valves are avail

able (Fig 162) without hand bulb Principles of use are the same as described above except hand bulb is not used

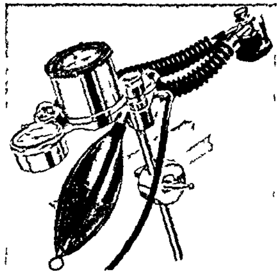
Intravenous Anesthesia

The technique is identical to that used for adults The doses and rate of administration is reduced in proportion Average for pentothal, surital, evipal is 0 30 gm per 50 lbs of body weight

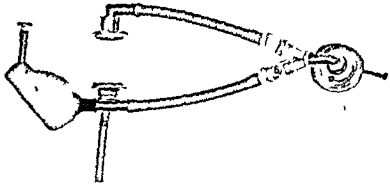
1 Cannulate vein, if procedure is long
2 Use small needles for short procedures

Pentothal Basal Narcosis and Nitrous Oxide

1 Technique same as for adults Average dose 0 75–1 0 gm per 50 lbs of body weight rectally



(a)



(b)

Fig 162 (a) Circle filter designed especially for infants and children The tubing mask mask holder valves and canister have been made smaller Technique and principles underlying its use are similar to those of adult types (Courtesy Ohio Chemical Company) (b) Circle filter designed by Leigh for infants and children (Courtesy Richard Foregger Ph D)

Rectal Anesthesia

Technique is same as described for adults (Part V) with exception of reduction in dosage

Spinal Anesthesia

Infants and children are not suitable subjects for spinal anesthesia because

1 They are psychically unsuited for the procedures
2 The cardiovascular responses are more variable than in adults
3 Response to physiological alterations more variable and unpredictable
4 Damage to cord possible because of infancy It extends further down than in adults

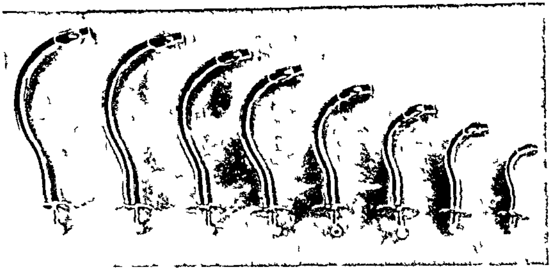


FIG 163 Airways of various sizes for use for infants and children (Courtesy Richard Foregger Ph D)

5 Offers no advantage, as far as relaxation is concerned, to general anesthesia
6 Extent of anesthesia not easily determined
7 Status of circulatory system (blood pressure) difficult to follow
8 Vasopressors not easily administered if hypotension results

Uses

1 When general anesthesia is contraindicated in older children
2 For diagnostic purposes—for autonomic derangements—megacolon

Procedure Basic principles and precautions outlined for spinal anesthesia in adults are used with following modifications

1 Have patient on side or upright to perform block
2 Premedicate to prevent squirming
3 Infiltrate skin and interspinous ligament with a local anesthetic
4 Make puncture below L3
5 Use shorter needle than used on adults—6–8 cms —22 or 24 G

6 *Drugs and dosages (average) are as follows*

1 hour or less Procaine 10 mgm for each year of age in 0 2 cc 5% dextrose

2 hours or less Pontocaine 1 mgm for each year of age in 0 2 cc 5% dextrose

3 hours or less Nupercaine 0 75 mgm for each year of age in 0 2 cc 5% dextrose

7 Place in supine position with head flexed sharply by placing folded sheet under neck

Preparation of Patient

Preparations, evaluation, recording etc are basically the same as for adults

1 Talk to patient, inspire confidence and avoid instilling fear
2 Premedicate with an anticholinergic drug, combined with a narcotic or an intramuscular barbiturate or a rectal or intravenous basal narcotic Use doses in Table VII
3 Attach stethoscope to chest for continuous auscultation of the heart
4 Attach blood pressure cuff 2″ wide for infants to right arm or above knee
5 *Restrain patient as soon as consciousness is lost and reflex activity* has disappeared

Premedication

Premedication is administered according to preference of the anesthetist, the status of patient and agent to be used The following are suggested

Subcutaneous Route Narcotics in combination with anticholinergic drugs (Table XVII)

Intravenous Route Seconal or pentobarbital ½ mgm per lb of body weight Pentothal—fractional doses of 1½–1 cc at 2–3 minute intervals until narcosis is obtained

Rectal Route Avertin—60–80 mgm per kilo of body weight (see Part V) Pentothal—1 gm per 50 lbs body weight (see Part V Rectal Anesthesia)

Comments and General Principles on Pediatric Anesthesia

1 Avoid drugs or drug combinations which are spasmogenic—pentothal ether, cyclo ether	Children are prone to develop severe laryngeal spasm
2 Have a set of infant size oropharyngeal airways on hand	Oropharynx varies considerably in size from child to child
3 Do not close mouth tightly when holding mask and supporting	Adenoid tissues may prevent free passage of gases through the nose

TABLE XVII

Age	Weight (lbs)	Morphine (gr)	Morphine Dilutions Dose—1 cc	Scopolamine Belafoline or Atropine
0–2 mos	7–10	1/480	gr 1/12 in 40 cc H_2O	1/600
2–3 mos	10–12	1/360	gr 1/12 in 30 cc	1/600
3–4 mos	12–14	1/240	gr 1/12 in 20 cc	1/600
4–7 mos	14–16	1/144	gr 1/12 in 12 cc	1/600
7–11 mos	16–19	1/120	gr 1/12 in 10 cc	1/600
11–18 mos	19–24	1/108	gr 1/12 in 9 cc	1/600
18 mos–2 yrs	24–27	1/72	gr 1/12 in 6 cc	1/450
2–3 yrs	27–30	1/60	gr 1/12 in 5 cc	1/450
3–5 yrs	30–40	1/48	gr 1/12 in 4 cc	1/450
5–8 yrs	40–55	1/36	gr 1/12 in 3 cc	1/300
8–10 yrs	55–65	1/24	gr 1/12 in 2 cc	1/300
10–12 yrs	65–80	1/18	gr 1/12 in 1.5 cc	1/200
12–14 yrs	80–90	1/12	gr 1/12 in 1 cc	1/150
	over 90	1/8–1/4		1/150

Demerol

12–23 lbs	5 mgm	34–45 lbs	25 mgm
24–27 lbs	13 mgm	45–55 lbs	37 mgm
27–30 lbs	15 mgm	55–80 lbs	50 mgm
30–35 lbs	18 mgm	80–90 lbs	100 mgm

Seconal

12–15 lbs	gr 1/4 to 3/8	30–55 lbs	gr 3/4
25–30 lbs	gr 3/8 to 1/2	55–90 lbs	gr 3/4 to 1 1/2

Nembutal

19–30 lbs	gr 1/4	50–80 lbs	gr 1
30–50 lbs	gr 1/2	80–90 lbs	gr 1 1/2

chin, if no airway is in place (Fig 163)	
4 Avoid nasal airways	Bleeding or obstruction due to adenoid tissue common
5 Avoid anesthetizing in hot, humid environment	Hyperpyrexia and convulsions common in summer months
6 Avoid rebreathing of even the slightest degree	CO excess may cause convulsions cardiac arrest, etc
7 Avoid use of heavy drapes or other objects on chest which inhibit respiratory movements	Hypoventilation leads to disaster more than any other cause
8 Measure pressure used to inflate lungs	Rupture of lungs avoided
9 Have an assortment of masks for selection and use as small a face piece as possible	The mask contributes excessive dead space
10 Take blood pressure on all types of procedures of even the slightest magnitude	Hypotension occurs as readily in pediatric as in adult cases

6. Drugs and dosages (average) are as follows

   1 hour or less Procaine 10 mgm for each year of age in 0 2 cc 5% dextrose

   2 hours or less Pontocaine 1 mgm for each year of age in 0 2 cc 5% dextrose

   3 hours or less Nupercaine 0 75 mgm for each year of age in 0 2 cc 5% dextrose
7. Place in supine position with head flexed sharply by placing folded sheet under neck

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Subcutaneous Route Narcotics in combination with anticholinergic drugs (Table XVII)

Intravenous Route Seconal or pentobarbital $\frac{1}{2}$ mgm per lb of body weight Pentothal—fractional doses of $1\frac{1}{5}$–1 cc at 2–3 minute intervals until narcosis is obtained

Rectal Route Avertin—60–80 mgm per kilo of body weight (see Part V) Pentothal—1 gm per 50 lbs body weight (see Part V Rectal Anesthesia)

Comments and General Principles on Pediatric Anesthesia

1 Avoid drugs or drug combinations which are spasmogenic—pentothal ether, cyclo-ether	Children are prone to develop severe laryngeal spasm
2 Have a set of infant size oropharyngeal airways on hand	Oropharynx varies considerably in size from child to child
3 Do not close mouth tightly when holding mask and supporting	Adenoid tissues may prevent free passage of gases through the nose

7 The angle between trachea and bronchi is more obtuse (120°) and same on both sides The angle changes with age
8 The trachea is short and intubation of a bronchus occurs easily
9 The nasopharynx contains an abundance of lymphoid tissue and nasal intubation is difficult or impossible
10 The mouth is small and does not accommodate the laryngoscope unless abbreviated for pediatric use
11 The trachea moves up and down (tugs) particularly in diaphragmatic breathers

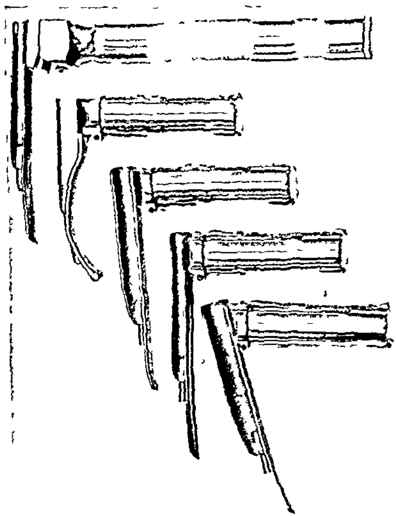


FIG 164 Laryngoscopes of various designs for use for infants and children (Courtesy Richard Foregger Ph D)

Technique The details, procedures, and materials needed are similar to those employed for endotracheal intubation in adults with modifications to conform to above anatomic and functional differences

Materials

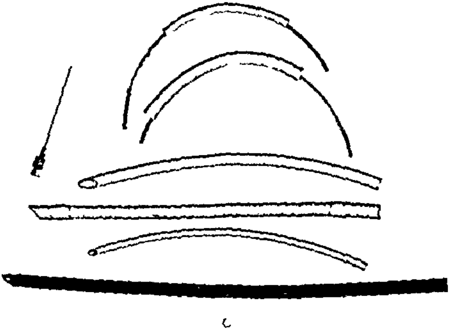
1 Infant laryngoscopes with small, medium and large blade of Miller and McIntosh type (Fig 164)

11	Expose chest during induction	Permits visualization of respiratory movements and detection of obstruction
12	Do not allow patient to exhale into an overdistended bag	Continuous positive pressure on airway reduces cardiac output and ultimately leads to circulatory collapse
13	Administer additional anticholinergic substance if secretions are excessive and persist	Does not "thicken" secretions as is erroneously claimed
14	Examine mouth and pharynx for foreign bodies	Chewing gum, beads, etc are often concealed by children
15	Deflate stomach by inserting stomach tube if distended	Improves respiratory exchange
16	Do not use "sugar teat" (cotton nipple filled with sugar and soaked with whiskey or brandy) for anesthesia—even during local anesthesia	Alcohol is not an anesthetic Secretions form and aspiration occurs frequently
17	Have all apertures to masks and tubes as wide as possible without being cumbersome	Obstruction is averted
18	Watch fluid administration carefully	Pulmonary edema occurs easily from overloading
19	Avoid anoxia at all costs	Asphyxia occurs easily in infants Anoxia is not tolerated

Pediatric Intracheal Anesthesia

Principle The differences in position and development and size of the larynx and other parts of the respiratory system in infants and children make intratracheal anesthesia more hazardous and difficult than in the adult The more pertinent differences are

1 The infant larynx is placed more cephalad than in the adult
   a At birth the lower border of the cricoid cartilage is at the level of the 4th cervical vertebrae
   b At the age of 6 it is at the level of the 5th cervical vertebrae
   c At the age of 12 it is at the adult level
2 *The epiglottis is longer, stiffer and U shaped*
3 The child's epiglottis is at an angle of 45° with the anterior pharyngeal wall
4 The infant's hyoid bone is closely attached to the thyroid cartilage
5 The cricoid ring is the narrowest point of the larynx In the adult the rima glottidis is the narrowest
6 The transverse diameter of the trachea is greater than the antero posterior



Top Plastic (polyethylene tubing) reinforced with rubber to prevent kinking with stylets *Center* Magill rubber catheter and wire woven latex tube *Bottom* Plastic dipped catheter

5 Non drying, non oily local anesthetic lubricant
6 Support for head—folded sheet or doughnut shaped pillow
7 A plastic catheter for suctioning to fit into lumen of intratracheal catheter
8 Sawed off needle of proper size This should be inserted at one end to connect to the suction tube

Procedure

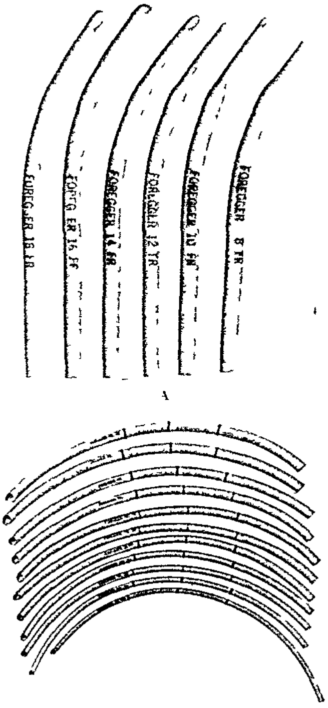
A *Oral Intubation*

1 Anesthetize patient to point of relaxation with cyclopropane, ether or pentothal—succinyl choline or other agent of choice
2 Place "doughnut" under the head and extend head
3 Remove mask and airway as soon as all details are readied
4 Introduce laryngoscope with left hand, in same manner as described for adults, at right side of mouth and work it over to midline
5 Pick up the epiglottis, remove secretions if necessary by suction and introduce the endotracheal tube
6 Introduce the bite block and remove laryngoscope
7 Connect tube to anesthetic apparatus and anchor
8 Pack pharynx lightly

B *Nasal Intubation*

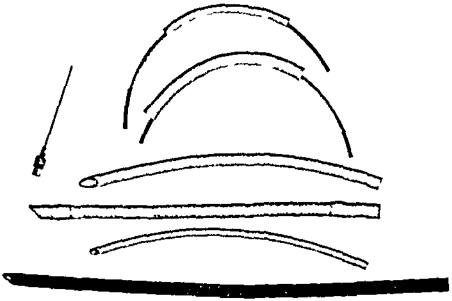
1 Anesthetize as for oral intubation
2 Introduce well lubricated Magill tube along into nostril until posterior pharyngeal wall is encountered (an obstruction results due to the adenoids)

2 Intratracheal catheters embodying following features (Fig 165)
   a As thin a wall as possible without losing its rigidity
   b The length from tip of nose to lobe of ear plus approximately 1/2 cm for each year of age of subject
3 Bite block constructed from partly used roll of small size bandage
4 An assortment of slip joints and connectors to fit the catheters



B

Fig 16. Endotracheal catheters for use for infants and children A. Cole tubes for infant anesthesia. B Plastic Magill tubes C (*at top of facing page*)



C

Top Plastic (polyethylene tubing) reinforced with rubber to prevent kinking with stylets *Center* Magill rubber catheter and wire woven latex tube *Bottom* Plastic dipped catheter

5 Non drying, non oily local anesthetic lubricant
6 Support for head—folded sheet or doughnut shaped pillow
7 A plastic catheter for suctioning to fit into lumen of intratracheal catheter
8 Sawed off needle of proper size This should be inserted at one end to connect to the suction tube

Procedure

A *Oral Intubation*

1 Anesthetize patient to point of relaxation with cyclopropane, ether or pentothal—succinyl choline or other agent of choice
2 Place "doughnut" under the head and extend head
3 Remove mask and airway as soon as all details are readied
4 Introduce laryngoscope with left hand, in same manner as described for adults, at right side of mouth and work it over to midline
5 Pick up the epiglottis, remove secretions if necessary by suction and introduce the endotracheal tube
6 Introduce the bite block and remove laryngoscope
7 Connect tube to anesthetic apparatus and anchor
8 Pack pharynx lightly

B *Nasal Intubation*

1 Anesthetize as for oral intubation
2 Introduce well lubricated Magill tube along into nostril until posterior pharyngeal wall is encountered (an obstruction results due to the adenoids)

3 Hyperextend the head and gently wiggle tube past this obstruction
4 Expose larynx and pass tube into the trachea, using forceps if necessary
5 Connect catheter and proceed as above

Comments

1	Cleanliness is of utmost importance Sterilize tubes and suction catheters and instruments used for intubation with alcohol or by boiling	Laryngeal edema and tracheitis may be caused by unsterile unclean instruments or chemical sterilizing agents
2	Inspect thorax and auscultate both sides after intubation	Labored breathing, lag, absent breath sounds or expiratory wheeze may indicate catheter is in a bronchus or obstructed
3	Inspect teeth before intubation Note status and missing ones	Deciduous teeth may be dislodged and lost particularly after age of 5 or 6
4	An oversize catheter may pass the vocal cords, but not into the trachea	The rim of the glottis is larger than the cricothyroid ring in infants
5	*Avoid the use of muscle relaxants*	*Not needed* Tissues of infants and children are easily relaxed Muscles are not fully developed
6	A catheter large enough for oral use usually passes through the nares	Undersized nasal catheters are often selected
7	Have an assortment of tubes of 3 *or 4 different lengths for a par*ticular diameter	Variations in distance from teeth *to carina much more frequent* than in adults for a given height and weight
8	Always use connectors of same internal diameter as internal diameter of tube	Obstruction results if fittings are smaller
9	Nasal catheter should be longer than oral	The distance is several centimeters greater for infants and 4–5 cms greater for adults
10	Do not attempt to use cuffs	Trauma, and encroachment upon lumen result
11	Use as thin walled, pliable and firm a tube as possible	In a 3 mm bore tube a 1 mm wall occludes cross sectional area 33%
12	Do not make repeated attempts to intubate	Edema invariably results from trauma
13	Extubate on expiration	Spasm occurs less frequently because the vocal cords relax on expiration

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Stephen, C R Pediatric Anesthesia Charles C Thomas Springfield Ill 1955
Adriani John, and Griggs T Rebreathing in Pediatric Anesthesia Anesthesiology, *14* 337, 1953

ANESTHESIA IN AGED (GERIATRIC) PATIENTS

Principle Technique of anesthesia for the aged is basically the same as for any adult subject to modifications prompted by factors listed below Selection of anesthesia is made upon physical status rather than chronological age Factors which are most frequently encountered or should be looked for which are due to senescence are as follows

1 Cardiovascular status Influence of degenerative or metabolic changes (arteriosclerosis, hypertension, pulmonary disease) may cause abnormalities
2 Respiratory system may be deranged (emphysema, bronchitis, fibrosis etc)
3 Renal function may be decreased Power of concentration diminished
4 Nutrition may be poor Diseases of digestive system may have interfered with proper assimilation resulting in weight loss, emaciation, anemia, avitaminosis, neuritis, etc
5 Liver function may be impaired due to fibrosis and other causes, ability to metabolize drugs is impaired
6 Metabolic rate lower It gradually decreases from fourth decade on
7 Metabolic diseases and degenerative diseases such as diabetes, nephritis, etc may be present
8 Blood volume may be contracted Anemia may be present
9 Mental disturbances, functional and organic may be present
10 Muscular system altered Atrophy, tremors, spasticity may be present
11 Skeletal system may be altered—fixation of joints due to arthritis
12 May have generalized tissue waste with atrophy of skin, mucous membranes and other structures
13 May be edentulate
14 Power of repair and ability to resist infections, shock, trauma diminished
15 Reflex activity diminished Cough, laryngeal, pharyngeal, corneal or pupillary reflexes may be decreased in activity

Principles to Observe

1 Avoid or use minimal doses of narcotics, hypnotics, basal narcotics for medication or pain relief Use 1/3 to 1/2 the ordinary adult dose Suggested dose of morphine for premedication is

40–60 yrs	morphine gr 1/6
60–70 yrs	morphine gr 1/8
70–80 yrs	morphine gr 1/12
80–90 yrs	morphine gr 1/16

2 Correct blood volume, anemia, disturbances in electrolytes, deficiency of serum protein, nitrogen balance, etc before operation
3 Digitalize patients who are in cardiac failure or borderline failure
4 Select agent or combination of agents which permit most rapid recovery, and early ambulation
5 Avoid agents or methods which cause variations in blood pressure or depress the cardiovascular system
6 Perform long procedures in two stages if possible

Evaluation of Drugs and Methods

Local and Nerve Blocks

Most desirable choice where feasible

Advantages

1 Causes least disturbances in metabolism, respiration or vascular system
2 Permit early ambulation

Disadvantages

1 Cannot be used in all situations
2 Operation may outlast block
3 Systemic reactions occur from absorption of excess amounts of drug
4 Epinephrine used in conjunction with local anesthetic may cause gangrene in extremities
5 Psychic makeup of patient may preclude its use

Spinal

Suitable only if the extent is low or if cardiovascular and respiratory systems are adequate

Advantages

1 Postoperative somnolence reduced to minimum allowing early ambulation
2 Nausea and vomiting reduced to minimum
3 Metabolic disturbances minimal

Disadvantages

1 Lumbar puncture may be difficult to perform
2 Hypotension occurs frequently may be severe and uncontrollable

Ether

Avoid wherever possible

Advantages

1 Wide margin of safety
2 Is not cardiotoxic
3 Does not depress respiration

Disadvantages

1 Slow recovery Ambulation delayed
2 Nausea, vomiting, dehydration, acidosis are frequent following its use
3 Disturbs metabolic functions—liver—kidney

Cyclopropane

Suitable when cardiovascular system is not diseased

Advantages

1 Rapid, pleasant induction and recovery
2 Labile Yields light or deep anesthesia at will
3 Permits adequate oxygenation at all times

Disadvantages

1 May cause cardiac irregularities
2 May elevate blood pressure
3 May cause laryngeal and bronchospasm
4 Depresses respiration

Ethylene

Very useful in aged

Advantages

1 Characterized by rapid induction and recovery
2 Disturbs metabolism little or not at all
3 Nausea minimal
4 Aged subjects less resistant to the drug Second and even top third plane anesthesia possible

Disadvantages

1 Flammable
2 May not yield desired relaxation at all times

Pentothal Nitrous Oxide and Other Thiobarbiturates

This is the only choice when fire hazard exists and general anesthesia is needed

2. Correct blood volume, anemia, disturbances in electrolytes, deficiency of serum protein, nitrogen balance, etc before operation
3. Digitalize patients who are in cardiac failure or borderline failure
4. Select agent or combination of agents which permit most rapid recovery, and early ambulation
5. Avoid agents or methods which cause variations in blood pressure or depress the cardiovascular system
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Ether

Avoid wherever possible

5 Hyperactive reflexes
   a Cough
   b Tracheobronchial
   c Vagal
6 Circulatory strain due to
   a Respiratory difficulty, anoxia, CO_2 excess
   b Existing cardiac disease
   c Fluid loss and shock
7 May be long and tedious and accompanied by blood loss

Management of Cases for Pulmonary Surgery

Comment	*Reason*
1 Delay operation to latter part of morning to institute postural drainage	Purulent material is evacuated from the lung before arrival in operating room
2 Intubate all patients especially if suppurative disease exists	Prevents build up of high intrapulmonary pressure (cough)
3 Bronchoscope patient preoperatively if suppurative disease is present and secretions are excessive	Provide clear airway
4 Aspirate frequently during operation if secretions are present	Secretions may accumulate without causing noisy breathing
5 Avoid non volatile drugs particularly narcotics	Cause depression of respiration which carries over to postoperative period
6 Use controlled respiration or assisted respiration	Ventilation with open chest is not adequate unassisted
7 Premedicate with anticholinergic drug	Vagal reflexes minimized Secretions reduced
8 Use inclined position by breaking table in V shape and tilt head down	Effects of gravity are utilized for drainage of secretions into trachea
9 Use endobronchial tube in suppurative diseases	Isolates one lung from the other
10 Introduce suction catheter quickly, aspirate once, oxygenate	Severe anoxia may be instituted by occluding the lumen of the catheter and application of suction
11 Infiltrate hilum with procaine when respiratory disturbances bradycardia, cardiac irregularities or "bucking" occurs	Troublesome vagal reflexes may be blocked
12 Replace fluid as it is lost	Avoid overloading the circulation Pulmonary edema follows

Advantages

1 Nitrous oxide permits reduction of total pentothal needed
2 Nausea and vomiting minimal

Disadvantages

1 Prolonged somnolence and depression may occur due to slow detoxification of pentothal
2 Relaxation not adequate at all times (use succinyl choline)
3 Anoxia a possibility

Avertin

Avoid Respiratory depression, hypotension and prolonged somnolence common

Trichlorethylene

Suitable for analgesia only

REFERENCES

Adriani, John Selection of Anesthesia Charles C Thomas, Springfield Ill , 1955
Lorhan, P Geriatric Anesthesia Charles C Thomas, Springfield, Ill , 1955

THORACIC SURGERY

Types

Thoracic surgery is of the following types

1 On the pleura and chest wall—decortications, drainage of empyema, thoracoplasty
2 On the lung proper—pneumonectomy, partial or complete
3 In the mediastinum—on the heart, great vessels, thymus or oesophagus

Problems Encountered

1 Diminished pulmonary reserve from pulmonary or cardiac disease giving rise to
   a Cyanosis, anoxia or CO_2 retention
   b Orthopnea and dyspnea
2 Diminished ventilation from lateral position required for operation and from the pneumothorax
3 Secretions, particularly when suppurative disease is present
4 Obstruction due to
   a Mass in chest compressing trachea or bronchi
   b Cord paralysis
   c Secretions

5 Hyperactive reflexes
   a Cough
   b Tracheobronchial
   c Vagal
6 Circulatory strain due to
   a Respiratory difficulty, anoxia, CO_2 excess
   b Existing cardiac disease
   c Fluid loss and shock
7 May be long and tedious and accompanied by blood loss

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13 Use supine position as often as possible	Lateral position undesirable because patient is on healthy lung Diminished ventilation and contamination result
14 Periodically (about every 20 minutes) inflate lung	Oxygenates blood in the collapsed lung
15 Apply blood pressure cuff to upper arm if patient is on side	Weight of body occludes vessel partly and sounds are inaudible if *the lower arm is used*
16 Pad shoulder and arm in prone or lateral position	Palsies due to nerve injury from traction and pressure may occur
17 Cocainize larynx prior to intubation and after	Abolish cough reflex which is often hyperactive in patient with chronic pulmonary disease
18 Use cyclopropane as agent of first choice and ether second choice	Assures quiet operative field Ether causes exaggerated breathing
19 Do not permit sustained positive pressure on the airway	Causes a decrease in cardiac output

Management of
Cardiac Surgery

Comment	*Reason*
1 Sedate with basal narcotic	Apprehension causes increase in cardiac activity which is detrimental
2 Monitor rhythm with electrocardiogram	Irregularities common when heart is manipulated
3 Use hypothermia in congenital lesions	Reduces metabolic activity of patient
4 Use drugs which do not increase cardiac irritability	Ether causes least irritability
5 Control respiration particularly if depression or hypoventilation is present	Carbon dioxide excess increases cardiac irritability
6 Be prepared for cardiac massage or to defibrilate heart	Sudden stoppage or fibrillation readily occurs without warning when heart is manipulated
7 Have available cardiac drugs—pronestyl, quinidine, procaine, calcium chloride	May be needed for reducing cardiac irritability
8 Avoid excessive amounts of antichlorinergic drugs	Increases pulse rate unduly
9 Use supine position whenever possible	Ventilation is more adequate

10. Limit fluids to blood lost	Overloading readily occurs resulting in cardiac failure
11. Block vagus if signs of hyperactivity appear	Procaine block may be performed directly

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Beecher, H. K. Principles and Practices of Anesthesia for Thoracic Surgery. Charles C Thomas, Springfield, Ill., 1955.

OBSTETRIC ANALGESIA AND ANESTHESIA

Obstetric analgesia and anesthesia differs from other forms of surgical anesthesia in the following respects:

1. Two physiologically and somatically different individuals are to be considered.
2. The patients are young and vigorous.
3. Patients are unprepared. They may have eaten or may be exhausted physically from long labor and may be emotionally upset.
4. Toxemia, hypertension, anemia, dehydration and other complications may be present.
5. Labor may be premature, in which case the fetus may be adversely affected by drugs and the obstetric procedure.

Analgesic Methods

1. A barbiturate (gr. 1½), meperidine (100 mgm.) and scopolamine (gr. 1/100) in early stages. Thorazine 25 mgm. may be used combined with half the barbiturate or meperidine.
2. a. Analgesia with nitrous oxide with each contraction until full dilatation occurs and the head is in position on perineum (Fig. 161).
   b. Analgesia with trichlorethylene by self administration or with nitrous oxide.
   c. Analgesia with ethylene.
   d. Continuous caudal block.

Anesthetic Methods for Uncomplicated Cases at Time of Application of Forceps

1. Cyclopropane for all types of vaginal deliveries.
2. Ethylene reinforced by ether.
3. Pentothal or nitrous oxide for short procedures.
4. Saddle block.
5. Caudal block.
6. Pudendal block.

HYPOTHERMIA DURING ANESTHESIA

Definition. The lowering of body temperature during anesthesia to reduce cardiac irritability and the total oxygen consumption. The body tem-

perature is reduced by depressing the thermoregulatory center with a central nervous system depressant and then placing the patient in a cold environment

Indications

1 Cardiac or extra cardiac operations on the great vessels of cyanotic infants and children

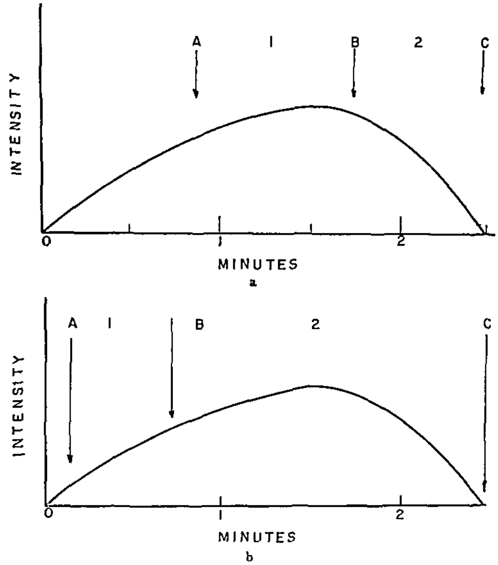
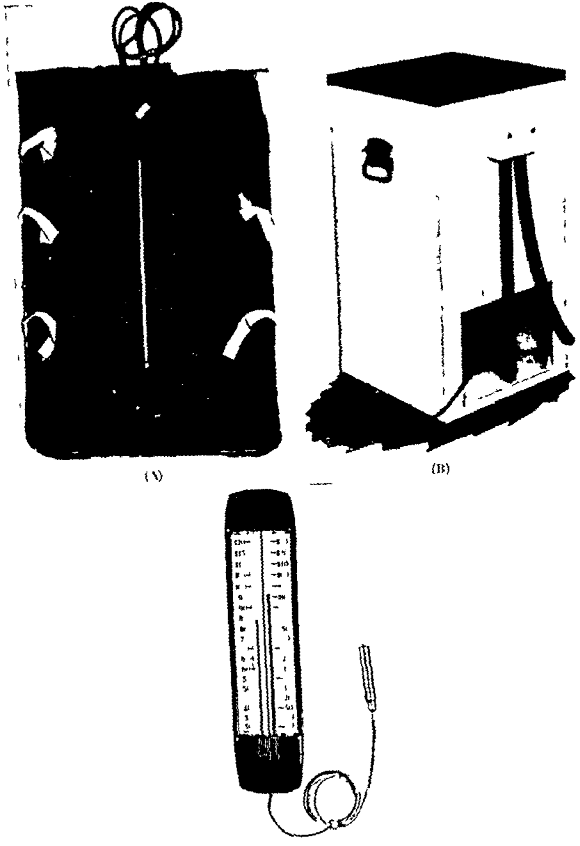


FIG 166 Nitrous oxide used for analgesia must be administered at the moment the patient senses the onset of an impending contraction so that analgesia will be established as soon as the peak of the contraction has been attained (A) When the administration is begun while the contraction is in progress analgesia may not be established until the pain begins to recede (B)

2 Operations which require complete interruption of the circulation for brief periods of time—resections of major vessels

3 Major surgery of any type in debilitated infants and children



(A) (B) (C)

FIG 167 A Blanket for inducing hypothermia composed of multiple coils through which ice water circulates It may also be used for controlling hyperthermia during and after operation B Reservoir and motor driven pump for circulating ice water C Indoor outdoor thermometer used for recording rectal temperature Outdoor portion is inserted into rectum

Methods of Cooling

1 Placing ice packs around patient on table
2 Placing subject in a deep freezing unit
3 Immersion in tub of ice water
4 Placing on a specially devised ice blanket

Materials

1 Direct writing electrocardiograph
2 The usual anesthetic apparatus, endotracheal equipment for closed technique (cuff)
3 Cooling blanket, refrigerating unit, numerous ice bags or tub for sub merging patient (Fig 167)
4 Ice
5 Water
6 At the conclusion of anesthesia, warm water at 42–44° C or diathermy machine
7 A thermocouple or recording thermometer equipped with bulb which can be introduced into the patient's rectum (Outdoor portion of outdoor-indoor thermometer may be used)
8 Intravenous procaine (2% in 5% glucose in distilled water) optional

Technique (Blanket)

1 Premedicate with a narcotic and an anticholinergic drug 1 hour prior to induction of anesthesia
2 Anesthetize with cyclopropane pentothal or other desired agent
3 Intubate with a cuffed tube using a muscle relaxant if necessary to augment anesthesia and set up closed system with carbon dioxide absorption
4 Cannulate a vein with polyethylene tubing and commence 0 2% pro caine (optional) in 5% glucose distilled water at a rate of 30 to 60 drops per minute
5 Introduce bulb of a thermocouple or thermometer into the patient's rectum and set recording mechanism in operation or record tempera tures on chart every 5 minutes
6 Attach electrocardiographic leads to limbs
7 Place the patient on the cooling blanket and commence the flow of cold water through the blanket (Fig 168)
8 Cool to 26° C —Prepare in advance Allow one hour for cooling period
9 Perform operation
10 Run warm (40° C) water through blanket

Technique (Tub)

1 Induce anesthesia with desired agent, intubate as described above
2 Connect rectal thermometers as described above

3 Immerse patient in tub filled with sufficient ice and water to submerge entire body except the head
4 Cool to desired temperature and remove from tub
5 Place on table and attach electrocardiograph
6 Perform operation
7 Remove to tub containing water at 40° C and warm to 28° C quickly (See page 473)

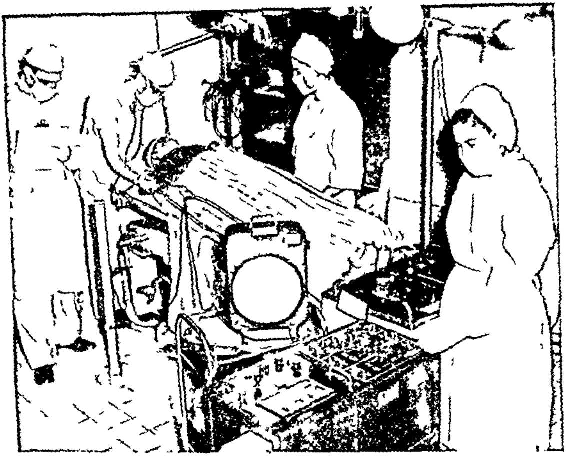


Fig 168 Inducing hypothermia in the operating room

Technique (Ice Bags)

1 Induce anesthesia and make preparations as above
2 Place ice bags in axilla, over groin, under back, along thighs and cover body with rubber sheet or blanket

Signs of Anesthesia and Appearance During Hypothermia

1 The skin has cherry red color where in contact with water
2 Lungs slow to deflate after artificial inflation
3 Pupils dilated particularly during ether, also during recovery
4 Planes and stages of anesthesia are nullified as patient is cooled
5 Spasticity of muscles may occur Use relaxant

Complications

1 Ventricular fibrillation may develop if cooled below 26° C
2 Frost bite may occur (usually in deep freeze technique)
3 Subcutaneous fat necrosis

Contra-Indications

1 The presence of acquired heart disease
2 Surgery of the heart in non cyanotic infants and children (left sided lesions)
3 For operations not requiring interruption of the circulation

Comment	*Reason*
1 Monitor the heart rhythm by continuous electrocardiography	(a) Electrocardiograms show changes, usually prolonged PR and ST intervals (b) Sinus rhythm predominates in temperatures above 23 3 C (c) Ventricular fibrillation occurs easily Once it occurs it is difficult to reverse (d) Pulse rate is accelerated initially then becomes slower at lower temperatures
2 Prevent shivering by adding intermittent doses of pentothal or deepening anesthesia	Shivering may precipitate ventricular fibrillation or exhaustion Cooling ceases when shivering begins
3 Be prepared to do controlled respiration	Apnea occurs when body temperature falls below 28°C
4 Hyperventilate throughout operation	CO_2 excess occurs readily and causes ventricular fibrillation
5 Do not have full weight of blanket on thorax	Water is heavy and respiratory movements may be inhibited
6 Cool to above 5° (about 60%) of desired temperature Allow ample time for cooling	Temperature may continue to drop another 5° after cooling is stopped
7 60 to 90 minutes are required for cooling for the blanket technique, several hours with ice bags, 20 minutes with tub	Use bath tub on wheels for adults or small wash tub for infants
8 Use thermometer to test temperature of warming water	Testing by hand has led to use of too hot water and burns have resulted
9 Warm by artificial means at conclusion of operation	Natural warming may require 10 hours

10. Hyperventilate to raise pH to 7.5 when circulation is occluded	May prevent accumulation of CO_2 to point of ventricular fibrillation
11. Discontinue addition of agent below 28°C	The cold acts as anesthesia
12. Inject 0.25 to 0.5 mgm. prostigmine intravenously when desired temperature is attained 3/5 of maximal cooling	Prophylaxis for ventricular fibrillation
13. Warm rapidly at conclusion of operation (use diathermy—Virtue's technique)	Audible blood pressure is obtained before wound closure
14. Allow rectal thermometer to remain in situ several hours after warming	Rectal temperature may arise above normal. Cool with ice bags or on ice blanket
15. Monitor heart with electrocardiogram for several hours postoperative	Cardiac irregularities may develop
16. Warm if fibrillation develops	More easily reversed at near normal temperature
17. Avoid tight fastenings of cuff, E.K.G. leads, etc.	Necrosis develops easily
18. Be prepared to do a thoracotomy during period of cooling	Ventricular fibrillation may develop from deep anesthesia and cold
19. Avoid arm or nerve traction	Injury and necrosis may result
20. Replace blood as needed	Blood volume must be maintained at adequate levels

REWARMING AFTER HYPOTHERMIA

Methods

a. By running warm water through blanket
b. By immersing in warm water in tub
c. By use of diathermy coils (method of Virtue)

Procedure Using Diathermy

1. Wrap 1" felt around abdomen and hips
2. Wrap coils around felt
3. Allow patient and wrappings to rest on wood strip, the ends of which are supported 2" above operating table
4. Support legs and upper part of body with short mattresses
5. Use diathermy at 2 minutes on and 1 minute off

Comment	*Reason*
1. Do not allow body to rest on coils	Burns may result
2. Watch circulatory system as 32° is approached	Pallor, circulatory collapse may develop

3 Use 50% nitrous oxide if patient is restless during warming	Awakening and reflex activity reappear at 34° May be unruly
4 Consciousness returns at 32° (lower rectal temperature) with surface warming	Heat is applied to entire surface of body With diathermy it is localized
5 Do not rely upon packs and hot water bags for rewarming	This method is not efficient
6 Always measure temperature of warm water with thermometer	Burns may result if this is not done

REFERENCE

Virtue Robert Hypothermia Charles C Thomas, Springfield Ill, 1955

Refrigeration Anesthesia

Definition Anesthesia obtained by the application of ice or iced water to tissues until insensibility to pain is obtained

Uses

1 For producing insensibility for amputation of limbs, for gangrene, devitalization of tissues, etc
2 To arrest hemorrhage, relieve pain, or to minimize devitalization of tissue in extremities in crushing injuries Metabolism of the cells is decreased

Materials

1 Cracked ice (1″ to 2″ pieces)
2 One large pail of several gallons capacity
3 Rubber sheet approximately 3′×4′
4 One medium sized pillow
5 Tourniquet composed of gum rubber tubing half inch in diameter
6 Large clamp or sponge holder for tourniquet
7 Six ice bags
8 Roll of bandage (2″ wide)

Premedication Morphine and scopolamine one hour prior to the operation

Procedure

1 Place the rubber sheet under the extremity so that it may be wrapped completely about it to form a gutter and so that the roll projects 8″ to 10″ over the end of the bed over the bucket
2 Elevate the extremity upon the pillow to allow blood to drain from the vessels
3 Surround the region of the proposed site of the tourniquet with ice bags for half an hour to minimize pain

4 Apply one turn of the tourniquet about the extremity This first wrapping should occlude the circulation
5 Apply a second wrapping over first and fasten the ends securely with the clamp to prevent slipping
6 Place a layer of ice upon the sheet and place extremity upon this layer of ice
7 Surround the entire extremity with ice beginning one or two inches proximal (above) to the tourniquet and extending to the end of the limb
8 Encircle the rubber sheet about the extremity and secure it with several turns of bandage
9 Allow the end of the roll of the rubber sheet to project over the edge of the bed so that the water from the melting ice drips into the bucket
10 Allow the limb to cool as follows

Foot—1 hour	Upper third of leg—2 hours
Lower leg—1 1/2 hours	Midthigh—2 1/2 hours

11 Remove the patient to the operating room, place on the table, unwrap the extremity as soon as all preparations for surgery are made and the surgical team is ready
12 Dry the extremity without rubbing, drape and prepare quickly in the desired manner (leave tourniquet in place)
13 Arrange to follow blood pressure and pulse, etc , as for other types of anesthesia

Duration of Anesthesia Approximately 30 minutes

Advantages

1 No inhalation or other type of anesthesia by drugs is necessary
2 Shock during surgery is minimal
3 Lowered temperature reduces oxygen and other metabolic requirements of the extremity
4 Low temperature reduces metabolism of cells
5 May be used postoperatively to reduce pain

Disadvantages

1 Period of insensitivity to pain may not outlast operation
2 Cumbersome in its execution
3 Reduced temperature interferes with healing (postoperative use)

Contra Indications None

Comments

1 Do not remove tourniquet until all blood vessels are tied and apparently satisfactory hemostasis is obtained

3 Use 50% nitrous oxide if patient is restless during warming	Awakening and reflex activity reappear at 34° May be unruly
4 Consciousness returns at 32° (lower rectal temperature) with surface warming	Heat is applied to entire surface of body With diathermy it is localized
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3 Surround the region of the proposed site of the tourniquet with ice bags for half an hour to minimize pain

Present Technique Using Ganglionic Blocking Agents

A *Arfonad*

1 Anesthetize patient with desired anesthetic such as pentothal nitrous oxide or cyclopropane Intubate using topical anesthesia and succinyl choline if desired
2 Canulate a vein to be prepared for infusion and transfusion
3 At approximately 10 minutes before anticipated time for need for the hypotension commence drip of drug (arfonad 0 1% solution in 5% dextrose—1 mgm per cc) and quickly reduce blood pressure to 80 or less, 75–150 mgm may be required
4 Maintain infusion at a rate to keep blood pressure at hypotensive level 1–1 5 mgm per min Dose varies for each patient
5 Tilt head down or feet down to raise or lower blood pressure as required

B *Hexamethonium*

Same technique as above except 20–25 mgm of drug are given into infusion tubing in single injection Dose varies from 5–35 or 40 mgm May have to be repeated several times before effective blockade occurs

Advantages of Arfonad over Hexamethonium

1 Arfonad is more rapid acting and its action is of shorter duration and therefore permits greater control

Technique Using Spinal Anesthesia (see Spinal Anesthesia Section for details)

1 Induce spinal anesthesia using 150–200 mgm procaine and steep Trendelenburg position to have level above T4
2 Use continuous spinal technique

Advantages of Ganglionic Blockade over Other Methods

1 Greater degree of controllability
2 Sensitivity to epinephrine and vasoconstriction remains
3 May be interrupted or reversed with greater ease
4 Vasoconstrictor effects are absent

Comment	*Reason*
1 Elevate blood pressure by tilting head down during blockade	Autonomic denervation inhibits centers for vasomotor control and the blood shifts to dependent areas
2 Replace blood as lost to avoid irreversible shock	Sympathectomized subjects do not stand severe blood loss
3 Lower blood pressure below 80, but not below 60 mm systolic	Renal and cerebral damage result

2 Observe blood pressure, pulse, and respiration closely during surgery
3 Administer a barbiturate or other sedative prior to initiation of cooling process
4 Use sufficient ice and keep limb well covered to insure success
5 Use cold solutions for irrigations, sponges, etc, during the operation This prevents extremity from becoming warm too quickly
6 Always use a tourniquet It prevents chilling of the remainder of the body but allows thorough chilling of limb
7 Employ a pure elastic narrow tubing for tourniquets

REFERENCE

Allen, F M, Crossman, L W, et al Refrigeration Anesthesia Anesth & Analg *21* 241, October, 1942

INTENTIONAL HYPOTENSION (HYPOTENSIVE ANESTHESIA)

Description The deliberate lowering of blood pressure during anesthesia to reduce blood loss in procedures in which excessive bleeding or acute hemorrhage is anticipated

Rationale Subjects whose autonomic nervous system is denervated withstand periods of hypotension due to hemorrhage for longer periods of time that those whose vasomotor systems are intact

Methods of Induction

1 By use of central depressants (narcotics, basal hypnotics and hypotensive agents) which depress the medullary centers
2 By use of high spinal block by inducing spinal anesthesia with a dilute solution of procaine
3 By use of ganglionic blocking agents (hexamethonium, arfonad or pendiomide)
4 By use of sympatholytic agents (priscol, regetine, thorazine)
5 By use of smooth muscle depressants (nitrites)
6 By reducing blood volume by use of arteriotomy (does not denervate blood vessels)

Situations in Which it is of Value

1 Resection of malignant or highly vascular neoplasms about head, face, neck, pelvis or other areas
2 Resection of highly vascular intracranial tumors or aneurysms
3 Resections of major vessels, fenestration operations, or other operations in which hemorrhage nullifies results
4 Pelvic eviscerectomies and other radical resections for carcinoma which are accompanied by bleeding
5 Hemisection of the kidney for removal of calculi, neoplasms, etc
6 Unavailability of rare types of blood or inability to match incompatable subjects for transfusion

"CONTROLLED" RESPIRATION

Definition The continuance of pulmonary ventilation by artificial methods during a deliberately induced apnea produced by inhibiting the stimulus to respiration

Uses

1 To provide an intermittently motionless field in thoracic and abdominal surgery
2 To provide adequate saturation of tissues with gaseous and volatile anesthetic drugs in the face of respiratory depression

Principle The apnea in controlled respiration is the result of one or a combination of these three factors

1 The removal of enough carbon dioxide from the alveoli and blood by hyperventilation so that the normal stimulus no longer exists
2 A decrease in sensitivity of the respiratory center by depressant drugs so that its threshold to carbon dioxide is raised
3 Stimulation of the Hering-Breuer reflex by overdistension of the alveoli so that the inspiration is inhibited

Procedure

1 Anesthetize the patient with cyclopropane or ether by carbon dioxide absorption technique and attain the desired depth of anesthesia The patient should be heavily premedicated
2 Intubate patient and secure an entirely leakproof system (use either the open or closed intra tracheal techniques)
3 Augment the volume of respiration by compressing the breathing bag during inspiration
4 Allow the lungs to empty quickly by releasing bag promptly during expiration
5 Omit pressure after eight or ten inspirations, and note if voluntary respiratory movement occurs when inflation is halted
6 Continue ventilation by manual pressure on the bag at the rate and volume of exchange comparable to rate during normal sleep Add anesthetic agent and oxygen as required
7 Judge depth of anesthesia by observing the reflexes in the eyes and muscle tone

Comment	*Reasons*
1 Observe circulation closely throughout the entire period of artificial ventilation	The circulation is impaired by the positive pressure which decreases the venous return to the heart and reduces cardiac output
2 Always establish an absolutely	The stomach is often inflated when

	from impaired blood flow if below 60 Bleeding not overcome if above 80
4 Do not allow hypotension to persist for more than one hour	Cerebral damage or anuria may result
5 Lighten anesthesia during period of hypotension	The amount of agent necessary to maintain anesthesia is reduced during period of decreased pressure
6 Watch body temperature	May fall during hypotension Vasodilatation causes heat loss and heat regulating center is depressed also
7 Reduce blood pressure quickly and maintain it at desired level Do not permit it to rise	Tachyphylaxis develops after repeated administration in some subjects and patient becomes refractory to drug
8 Watch patient closely until blockade has worn off	Blood pressure may continue to fall after procedure is completed
9 Use vasopressors cautiously	Patients may be more sensitive to these drugs while blockade is in progress
10 Keep head as much as possible at level of or below level of heart	In the head up position the blood pressure in the head is lower than in the rest of the body because the blood shifts to dependent portion due to vascular atony

Complications

1 Reactionary hemorrhage due to inadequate hemostasis
2 Prolonged depression in postoperative period
3 Thrombosis of cerebral and coronary arteries
4 Oliguria or anuria postoperatively
5 Cerebral damage due to impaired nutrition of cells
6 Unexplained cardiac arrest

Contra Indications

1 Arteriosclerosis with well defined changes in most vessels
2 Essential hypotension and hypotension due to other causes
3 Impaired renal function
4 Anemias of all types (uncorrected)
5 Heart disease particularly advanced coronary artery disease
6 Liver dysfunction

REFERENCES

Hale D F Controlled Hypotension Anesthesiology 16 1 1955
Little D Hypotensive Anesthesia Charles C Thomas Springfield Ill 1956

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Little D Hypotensive Anesthesia Charles C Thomas Springfield, Ill 1956

Fig 169 Automatic 'breathing machine' for controlled respiration (Jefferson) The apparatus utilizes compressed air as source of energy Positive pressure is made by raising the pressure on the exterior of the bag Negative pressure may also be applied during expiration A lever permits instant shift from mechanical to manual controlled respiration or normal breathing (Courtesy Air Shields Company)

Settings for Controls

Phase

Equal duration of inflation (positive pressure) phase and deflation (negative pressure) phase appear to be satisfactory with both open and closed thorax

Pressure

Open Thorax 15 cm H_2O positive and 5 cm H_2O negative with equal phasing

Closed Thorax 10 cm H_2O positive and 10 cm H_2O negative with equal phasing

clear airway An endotracheal airway is desirable but not imperative	pharyngeal airways are employed
3 Do not attempt controlled respiration during the period when the tracheal reflex is active	Lungs are difficult to inflate during active coughing stage and a high degree of positive pressure is established in the inhaler
4 Secure a leakproof system for optimum results	Loss of anesthestic mixture results in uneven depth of anesthesia
5 Do not exceed a pressure of 20 cms of water to inflate lungs Use a manometer	Excessive pressure may be dangerous and cause trauma to the alveoli

REFERENCES

Guedel, A E, and Treweek, O N Ether Apneas Anesth & Analg *7* 238 1928
Waters, R M Absorption of Carbon Dioxide from Anesthetic Atmospheres Proc Roy Soc Med, *34* 11, 1936

CONTROLLED RESPIRATION USING THE MECHANICAL (JEFFERSON) RESPIRATOR

Description Various insufflators are available for artificially respiring patients with mixtures of anesthetic gases or vapors and oxygen The Jefferson ventilator (Fig 169) inflates the lungs with a stream of gases under positive pressure Varying degrees of negative pressure may be applied on expiration The gases circulate through the circle filter in the same manner that the patient circulates them using voluntary breathing The apparatus is used as follows

1 Induce apnea by hyperventilation or by use of muscle relaxant
2 Remove rebreathing bag from anesthetic apparatus and attach flexible hose from ventilator
3 Attach rebreathing bag from anesthesia apparatus to vertical leg of T-valve
4 Turn T-valve to manual position
5 Turn negative and positive pressure controls counterclockwise to their limit
6 Connect pressure hose to any standard oxygen flowmeter or regulator Set flow high enough to maintain 12 pounds pressure on gauge just below timer
7 *Partially* inflate rebreathing bag in glass control by turning T valve to automatic, and adding oxygen to respiratory circuit
8 Make desired control settings (see below) then turn T valve to automatic position

4 Effects on circulation difficult to predict, usually adverse particularly if pressure does not return to zero or subatmospheric on expiration

Comment

1 To clean or replace internal rebreathing bag lift entire gauge and I-valve assembly straight up
2 Flowmeter settings of 12–14 liters per minute are required to maintain proper operating pressure However actual consumption is 6–8 l p m
3 Use compressed air instead of oxygen as a source of pressure to operate machine if desired
4 Change soda lime canister frequently because of the greater ventilation provided
5 Switch to "manual" when aspirating the trachea, or when a bronchus is open to avoid loss of anesthesia gases Do not turn off ventilator when on "manual" It continues to operate
6 Make suitable adjustment of pressure settings to insure maintenance of safe and effective mean lung pressure if relative duration of inflation phase is changed from two to one
7 *Always* keep rebreathing bag inside control *partially* inflated

POSTANESTHETIC RECOVERY ROOM

Definition The postanesthetic recovery room is a special room for observing and attending patients recovering from anesthesia It should possess the following features

A 1 Should be on the same floor as and close to operating room
2 Should be properly warmed (winter) and air conditioned (summer) and free from drafts
3 Should be a well lighted single open square or oblong space so that patients can be seen from any part of room
4 Should lead into a corridor not traversed by visitors and non medical personnel Corridor should be wide enough to permit turning of a bed or roller
5 Should be equipped with wide doors to permit passage of rollers, portable x ray equipment, oxygen tents, etc
6 Should be large enough to accommodate desired number of rollers or special recovery room beds so that they are at least 3 feet apart
7 Should have outlets for piped oxygen, double electric plugs and wall suction at each bed or roller station
8 Should have terrazzo asphalt tile or other easily cleaned floor (need not be conductive)
9 Should be adjacent to laboratory for doing urine, blood counts and hematocrit

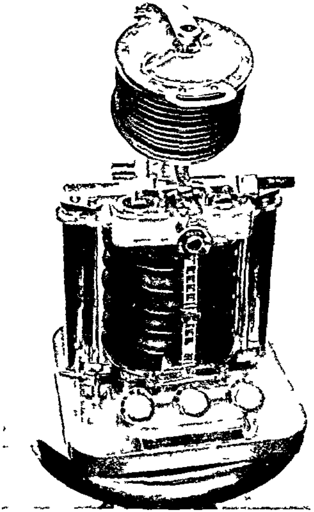

FIG 169a The Stephenson mechanical ventilator (designed by Goodner) utilizes a bellows to assure delivery of a fixed volume of gas for controlled respiration The desired tidal volume can be set by adjusting the sliding vertical scale The apparatus is connected by means of a corrugated tube to a standard anesthetic apparatus of either the circle or to and fro design in place of the breathing bag The mechanism operates by compressed gas or oxygen Respiratory rate duration of inspiration duration of expiration and length of inter respiratory pause are adjusted by means of dials at the base The sliding weights on the beams are adjusted to deliver the desired positive pressure and the pressure necessary to overcome any resistance in the airway or apparatus Varying degrees of negative pressure during the expiratory phase of respiration may be applied by adjusting the sliding weight along the beam on the right An auxiliary (safety) bellow is provided at the top to act as the breathing bag before the mechanism commences to operate or when obstruction or mechanical failure causes interference with delivery of the set volume of gas

Rate

Respiratory rates in the order of 18 to 20 per minute appear to provide adequate ventilation for most patients

Disadvantages of Mechanical Methods of Controlled Respiration

1 Depth of anesthesia not easily estimated during artificial ventilation
2 Volume of gas delivered not known with most devices
3 Machines may continue to appear to operate if obstruction occurs and lungs are not being inflated

4 Effects on circulation difficult to predict, usually adverse particularly if pressure does not return to zero or subatmospheric on expiration

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9 Should be adjacent to laboratory for doing urine, blood counts and hematocrit

10 Should have ample closet, storage and cabinet space for supplies

B *Beds*

Recovery room beds or rollers (Fig 169b) should be sturdily constructed preferably of stainless steel and have the following features

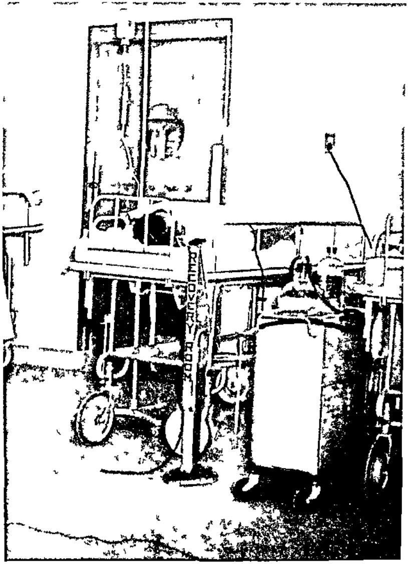

FIG 169b Recovery room combination roller and bed

1 Wide enough to permit patient to be rolled on side with comfort and safety
2 Large casters equipped with conductive rubber type or grounded by chains
3 At least 3 feet from floor—to permit easy care and removal from operating table and to ward bed
4 Tiltable at head and foot end to permit head down or head up position
5 Locking mechanism for wheels

6 Side boards and head and foot ends which are removable for bronchoscopy, venipuncture and other treatment, etc
7 Infusion stand placeable at foot, head or side of bed
8 Arm board which can be placed at either side
9 Straps for restraining and anchors for them on bed
10 Shelf beneath for placing suction bottles and other equipment
11 Hooks for hanging suction bottles, catheter draining bottles etc
12 Comfortable washable rubber covered matress pad

C *Materials—Resuscitative for Ventilation*

1 Tracheotomy set
2 Suction apparatus for aspiration of respiratory tract (catheter and tonsil suction)
3 Set of airways, oral and nasal
4 Set of endotracheal catheters (plastic)
5 Laryngoscopes with assortment of blades
6 Aspirating bronchoscope (Davis)
7 Mechanical insufflator for resuscitation—Stanton, Kriselman, to and fro etc
8 Pneumothorax set and water trap
9 Availability of Iron Lung (for respiratory paralysis—head injury, brain injury etc)

D *Materials—Resuscitative for Circulation*

1 Cardiac arrest set (scalpel, rib spreader, hemostats) sterile and ready to use
2 Defibrillator and pacemaker
3 Arterial transfusion set
4 Ordinary transfusion sets
5 Sternal puncture needle for infusion into bone marrow
6 Blood pressure apparatus (cuff and stethoscope)
7 Phlebotomy set

E *Oxygen Therapy Unit*

1 Tent (adult) O E M mask and catheter equipment
2 Tent (infant), Croupette or similar type with nebulizer for water
3 Bennet positive pressure device for treating pulmonary edema
4 Coughlator or similar exsufflator
5 Carbon dioxide, 5% oxygen with semi closed mask and flow meter
6 Nebulizers for aerosol therapy

F *Surgical Supplies*

1 Syringes and needles of various sizes for medications and aspiration
2 Emesis basins

10 Should have ample closet, storage and cabinet space for supplies

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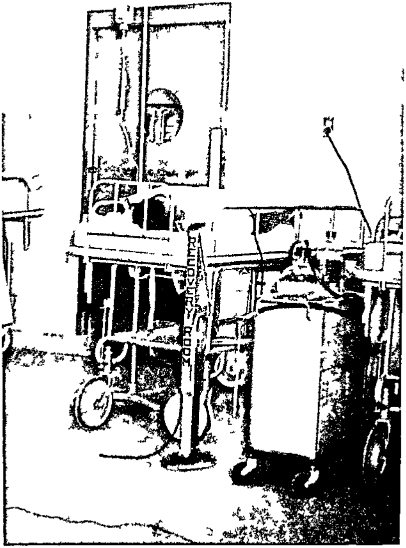

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   2 Chlortrimeton
   3 Pyribenzamine
h Vasopressor Drugs
   1 Arfonad
   2 Hexamethonium
i Anti nausea Drug
   1 Marezine
   2 Dramamine
   3 Thorazine
j Fluids
   1 Blood
   2 Plasma
   3 Serum album
   4 Fibrinogen
   5 Dextran
   6 Normal saline
k Antibiotics and Chemotherapeutic Agents
   1 Streptomycin
   2 Penicillin
   3 Tetracycline
   4 Sulfa drugs

H *Personnel*

1 Graduate nurses trained in management of airways intravenous therapy inhalation therapy and surgical nursing should be in attendance constantly (one nurse per 2 or 3 patients)
2 Resident physician anesthetist or staff anesthesiologist should make rounds at frequent intervals and be available on call
3 Surgical residents available for surgical complications
4 Orderlies maids and ward aids

I *Duties of Recovery Room Personnel*

1 Maintain adequate airway
2 Watch respiration of patient—color, rate, depth
3 Restrain to prevent injury
4 Administer drugs required for sedation and supportive therapy
5 Watch circulatory system—pulse blood pressure etc
6 Prevent aspiration and pulmonary complications
7 Watch for bleeding
8 Watch fluid intake and output
9 General nursing care—catheterizing changing gowns, administration of narcotics and other drugs
10 Initiate or continue specialized therapy once it has been instituted by physician or technician

3 Gastric tubes
4 Rectal tubes and suction
5 Urinary catheterization set
6 Ice bags
7 Hot water bags
8 Ice cooling mattress for hyperthermic patients
9 Thermometers—oral rectal
10 Bed pans
11 Urinals
12 Ice box for storage of perishable drugs, blood, etc
13 Goose neck lamps for bedside therapy (venipuncture, etc)

G *Drugs*

a Respiratory—stimulants
1 Nallorphine
2 Metrazole
3 Picrotoxin
4 Coramine
5 Alpha lobeline
b Narcotics—for pain
1 Morphine
2 Demerol
3 Dilaudid
4 Nisentil
5 Methadon
c Barbiturates
1 Pentobarbital or Secobarbital for injection (drug reaction)
2 Phenobarbital
3 Pentothal
d Anti curare Drugs
1 Edrophonium (Tensilon)
2 Prostigmine
e Anti cholinergic Drugs
1 Atropine
2 Hyoscyamine
3 Scopolamine
f Cardiac Drugs
1 Pronestyl
2 *Quinidine*
3 Aminophylline
4 Procaine—5 cc ampules (20%) for I V use
5 Digitalis preparations
g Antihistaminic Drugs
1 Benadryl

O *Maintaining Airway*

1 Hold chin (Fig 75)
2 Turn patient on side
3 Aspirate saliva
4 Use airway if reflexes have not returned
5 Administer anticholinergic drug if secretions are excessive
6 Perform tracheotomy if supralaryngeal obstruction is present

P *Prevention of Aspiration*

1 Remove airways as soon as reflexes return to avoid gagging
2 Maintain in supine head down position
3 Connect stomach tubes to suction

Q *Prevention of Urinary Retention*

1 Catheterize every six hours or use retention catheter to prevent dilatation of bladder

R *Treatment of Nausea*

1 Hydrate (if ketosis or acidosis is present)
2 Discontinue narcotics or change to different type
3 Introduce Levine tube and lavage stomach
4 Use phenobarbital dramamine or thorazine

Comment

1 Do not allow visitors in recovery room
2 Place nurse's station so that all patients can be seen from her position
3 Have direct communication system by phone or speaker system to surgeon and anesthesiologist
4 Do not remove patients from recovery until fully reacted and danger of hypotension has passed
5 Remain with patient until vomiting is over
6 Instruct nurses never to leave patients alone at any time

TRACHEOBRONCHIAL ASPIRATION WITH CATHETER

Purpose To induce patient to cough in order to aspirate mucoid secretions from tracheobronchial tree Used for treating atelectasis and other pulmonary infections

Material

1 Magill catheter—29 F approximately, depending on size of patient
2 Jelly type lubricant containing local anesthetic (xylocaine, metycaine, Americaine, etc)
3 Suction or urethral catheter about 10 F which will pass through endo tracheal tube

J *Hours of Operation of Recovery Room*

1 Varies with size of hospital
Large institution—24 hours 7 days a week
Small—day time operation only Closed nights and holidays

K *Supervision*

The recovery room may be supervised in a number of ways Method depends upon local situation
1 Anesthesiologist only
2 Jointly by anesthesiologist and surgeon
3 By nursing service with assistance and advice of anesthesiologists and surgeon

L *Duration of Stay of Patients in Recovery*

1 Remain until all reflexes have returned and patient is rational and no artificial airway is needed
2 Remain until blood pressure has stabilized and possibility of shock is over
3 Remain until vomiting and nausea are over
4 Remain until possibility that movement and shifting will cause no circulatory depression

M *Records*

The following data should be recorded on a special recovery room chart or on the patient's regular chart
1 Time of arrival and discharge and condition upon arrival and discharge
2 Name of physicians visiting and treatments performed by them
3 Blood pressure, pulse, temperature, respiration, color, etc
4 Fluids and medication given from time of arrival
5 Therapy instituted and time of administration
6 Laboratory tests done or ordered
7 Time of recovery from anesthesia
8 Unusual episodes, and method of treatment

N *Prevention of Pulmonary Complications*

1 Turn patient from side to side frequently
2 Use narcotics sparingly
3 Encourage patient to breathe deeply
4 Induce coughing by endotracheal suction or aspirate in comatose patients
5 Ambulate as soon as possible

PART VIII

RESUSCITATION

Definition Resuscitation is *Restoration to life of the apparent dead* (*Webster*) It might be added that the dead cannot be revived

Subjects requiring resuscitation fall into three categories, according to the symptoms they present

1 Those with no signs of circulatory or respiratory activity *This is the most common picture encountered*
2 Those in whom *respiration* has failed, but *circulation* is still active This state is usually caused by depressant drugs, anesthesia, intra cranial and other nervous system lesions Circulation soon fails unless *treatment* is instituted
3 Those in whom respiration is active, but circulation is depressed—shock, spinal anesthesia, etc Respiratory depression or failure soon follows if the circulatory depression is not corrected

Treatment

1 If a patient is not breathing or respiratory movements are inadequate, institute artificial respiration *immediately*
2 If an assistant is available, he may administer an analeptic drug in conjunction with artificial respiration

Comment Do not neglect artificial respiration and waste time administering stimulating drugs The oxygen the patient needs in such circumstances cannot be administered with a syringe from an ampule! !

ARTIFICIAL RESPIRATION

Definition The process of maintaining as near as possible physiological oxygen and carbon dioxide tensions in alveoli by artificial methods when voluntary respiratory movements are absent

Methods There are numerous methods of artificial respiration All fall into one of these two following groups

1 *Manual* or *non mechanical* These are methods in which no apparatus is required
2 *Mechanical* These are methods which require some form of apparatus or machinery

Methods of artificial respiration are based upon one of these two principles

1 The principle in which an intermittent negative or positive pressure in the pleural space is produced by a force applied to the exterior of the

Procedure

1 Lubricate gently, introduce the Magill tube into one nostril which has no obstruction until larynx is reached
2 Have patient inspire deeply and at height of inspiration direct Magill tube into trachea
3 Pass suction catheter into Magill tube and remove secretions
4 Keep Magill tube in as long as patient tolerates until no further secretions are removed

Comments

1 In cases of atelectasis if lung fails to expand due to inability to remove secretions because they are too far down, perform bronchoscopy
2 In cases of excessive gagging or coughing anesthetize nasopharynx with local anesthetic spray

Advantages

1 May be instituted immediately by one operator
2 May be instituted by having the patient in the prone position
3 The tidal exchange is approximately 500–600 cc per minute, greater than any other manual method

Disadvantages

1 The airway may become obstructed because the patient is in the prone position and the airway is not under direct control of the operator
2 The method is not suitable for long periods because it is tiring to the operator

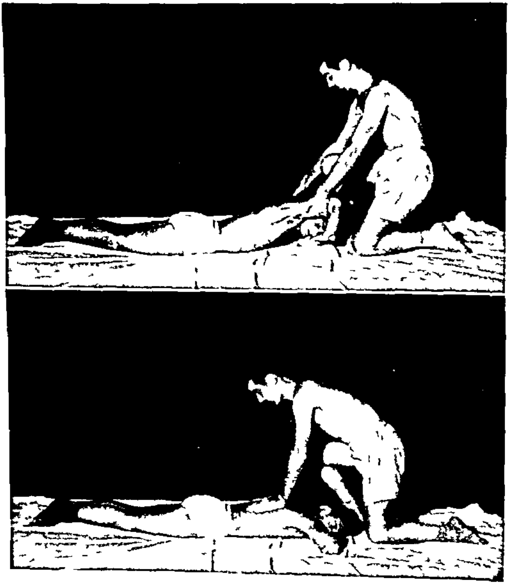

FIG 170 Maneuvers in performing Nielsen s method of artificial respiration (Courtesy Meyer Saklad Inhalation Therapy and Resuscitation Thomas Springfield 1953)

thorax or by causing the diaphragm to move The following embody this principle

a Nielsen's arm lift back pressure method (manual)
b Silvester's method (manual)
c Drinker's method (using the "iron lung," mechanical)
d Eve's method (using the tilt table)

2 The principle in which expansion of the thorax is produced by insufflating gases under pressure into the alveoli

The following methods embody this principle

a Insufflation by mouth to mouth breathing (non mechanical)
b Insufflation by an inhaler composed of mask, breathing bag and an oxygen supply (mechanical) The inflated bag is compressed manually
c Insufflation by an automatic mechanism The E & J, Emerson, McKesson and such insufflators are purely automatic mechanical devices

REFERENCE

Waters, R M Methods of Resuscitation Jour Lab & Clin Med, *26* 272–278, October 1940

NIELSEN'S METHOD (ARM LIFT—BACK PRESSURE TECHNIQUE)

Definition The establishment of respiratory movements by compression and relaxation of the thorax using the arm lift back pressure technique

Principle

1 *Inspiration*—Obtained by having the operator grasp the elbows and elevate them to create active inspiration
2 *Expiration*—Obtained by releasing the elbows and applying pressure over the scapulae
3 Oxygen tension—this is the same as that of the atmosphere
4 Carbon dioxide—this is the same as that of the atmosphere

Technique

1 Place the subject in the prone position with hands under the forehead
2 Kneel at the head and face the feet of the patient (Fig 170)
3 Grasp the patient's arms and raise them until the upper thorax is off the floor
4 Release the arms and allow the thorax to go back to the floor
5 Make pressure over the scapulae with both hands by leaning forward (Fig 170)
6 Repeat this maneuver rhythmically sixteen times per minute All movements should be gradual

3 *Oxygen Tension* This is the same as that of the atmosphere

4 *Carbon Dioxide Tension* This is the same as that of the atmosphere

Technique (Fig 171)

1 Place the patient in the supine position and lower his head and shoulders

2 Grasp patient s hands at the wrist Extend the patient's arms without

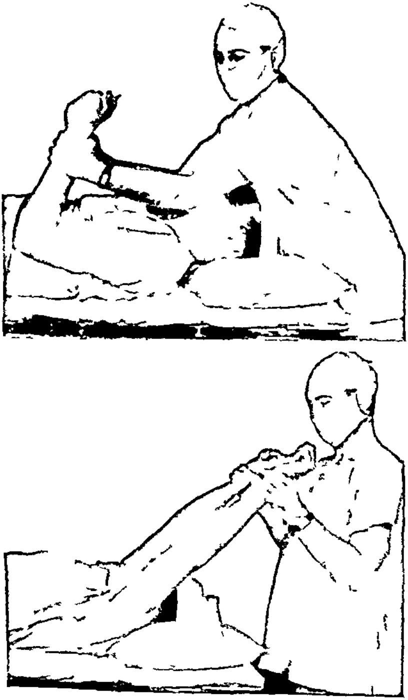

Fig 171 Silvester's method of artificial respiration

Insufflation by Mouth to Mouth Breathing

Definition The establishment of respiratory movements by inflating the patient's lung by breathing into the patient's mouth

Principle

1 *Inspiration* This is obtained by forcing the operator's exhalation into the alveoli
2 *Expiration* This is obtained by the elastic recoil of lungs and tissues of the chest wall
3 *Oxygen Tension* This is usually subatmospheric, 12%–15%, in the insufflated gas
4 *Carbon Dioxide Tension* This usually ranges from 3 to 5% in the insufflated gas

Technique

1 Place patient in the supine (face up) position
2 Extend the chin so that the head points upward to assure a free airway to the larynx If available, insert an oropharyngeal airway
3 Cover the patient's lips with gauze and pinch the patient's nose Place lips (operator's) to patient's and blow into his mouth 14 times per minute at even regular rate

Advantages

1 The method is immediately available It requires no special apparatus
2 It may be executed by anyone or delegated to assistants if necessary after a moment's instruction

Disadvantages

1 The oxygen tension of the insufflated air is below that of the atmosphere
2 The carbon dioxide from operator's exhalation introduced into an asphyxiated patient is not desirable
3 The excessive force exerted by adults may rupture alveoli of infants

Silvester's Method

Definition Establishment of respiratory movements by compression and relaxation of lower portion of the thorax with the patient's elbows

Principle

1 *Inspiration* This is obtained by expansion of the thoracic cage, by extending patient's arms over his head
2 *Expiration* This is obtained by compression of lower ribs and thorax with the patient's elbows

2 *Expiration* This is produced by the elastic recoil of lung tissue (or by positive pressure device on machine if desired)
3 *Oxygen Tension* This is the same as the atmosphere, unless oxygen is supplied by mask or catheter
4 *Carbon Dioxide Tension* This is the same as that of atmosphere

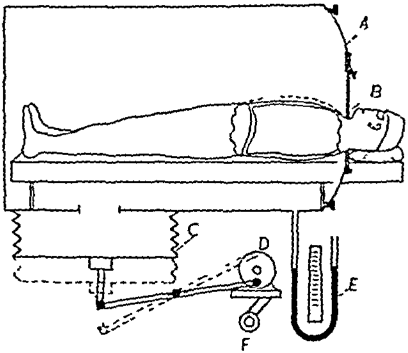

FIG 172 Schematic diagram of iron lung (A) Steel airtight enclosure. (B) Rubber collar (C) Movable diaphragm and bellows. (D) Motor for operating the diaphragm (E) Manometer for gauging changes in the pressure (F) Rheostat for controlling the rate of ventilation.

Technique

1 Unclamp the front, pull out the cot, adjust patient comfortably upon it and replace in chamber Lock clamps securely (Fig 173)
2 Turn on the switch which starts the respirator Regulate the rate to 14–18 times per minute (rate may be increased by adjusting rheostat which controls the motor)
3 Adjust collar so that it fits snugly and comfortably Pad with cotton if necessary Place the head upon the head rest
4 Regulate depth of respiration by adjusting negative pressure to approximately 18 cms water pressure Determine the threshold of the negative pressure to be employed by asking the patient to count out loud Increase the pressure to the point at which speech disappears This is the optimum pressure

Precautions

1 Be positive the airway is patent and air passes in and out of mouth (place hand over mouth to be certain) Insert a pharyngeal airway if it is tolerated by the patient *or if* the patient is unconscious

flexing at the elbow joint backward and upward over beyond head This expands ribs for inspiration
3 Return the patient's arms so that his elbows are flexed almost at a right angle with the humeri The elbows are placed along lower anterior chest wall Pressure is made on forearms so that the humeri compress the ribs and force air out of the chest
4 Repeat this maneuver rhythmically 16 times per minute All movements should be gradual

Advantages This method is useful when the patient must be maintained in a supine position (surgical cases)

Disadvantages

1 The airway becomes obstructed because the patient is in the supine position The tongue rolls back easily
2 The method is not suitable for long periods because it is tiring for the operator

REFERENCE

Silvester, H Restoring Persons Apparently Drowned or Dead British M J p 575, 1858

"IRON LUNG" OR DRINKER RESPIRATOR

Principle *An intermittent negative pressure is produced in an airtight steel* chamber by the alternate compression and relaxation of a large diaphragm The chamber encloses all of a patient's body but his head Atmospheric air is drawn into the lungs during the phase of negative pressure (Fig 172)

Apparatus A cylindrical chamber constructed to enclose an adult human being The chamber has the following features

1 A cot which slides out at head end of the chamber This is attached to the cover which is quickly clamped to body of the chamber
2 A sponge like collar fitting about the patient's neck to insure an air tight fit
3 A motor to operate the diaphragm to produce variations in pressure within the chamber
4 A manometer to record changes in pressure within the chamber
5 A regulator for varying pressure changes within the chamber
6 A rheostat to control the motor to vary the rate of respiration
7 A lever for hand operation of the diaphragm in event the power fails
8 Windows and port holes for administering treatments and examinations of patients

Principle

1 *Inspiration* This is produced by creating a negative pressure in pleural space by creating a subatmospheric tension about the thorax

to assist in deflating of the lungs Although they differ in many ways, all have some or all of the following features

1 They inflate the lungs by supplying a stream of oxygen to a mask As soon as a pressure of 14 to 18 cms of water is attained, the stream is automatically interrupted
2 They attempt to deflate the lungs by negative pressure induced by suction (9–12 cms of water)
3 They have a suction mechanism operated by the compressed gas to remove secretions
4 They are equipped with a valve which allows the apparatus to be converted to an inhaler to allow patients pure oxygen or oxygen and carbon dioxide
5 They are equipped with an automatic release which shuts off the stream of gases when calibrated pressure is attained in the mask

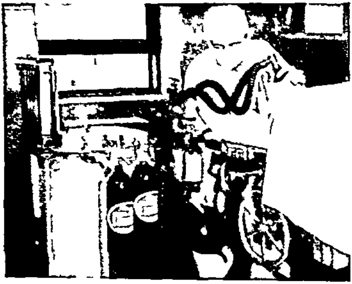

FIG 174 Artificial respiration by insufflation Use of circle filter for manual ventilation of lungs

6 They are equipped with a valve which institutes negative pressure when positive insufflation pressure is interrupted
7 They have a valve for varying the rate of inflation

Note Numerous models of this type introduced by different manufacturers are available For each model the instructions provided by the manufacturer should be followed The E&J is the better known and its use is described below

Use of E&J Resuscitator (*Fig 176*)

1 Turn oxygen cylinder valve on completely
2 Turn operating lever to "resuscitator" side if on "suction" or inhaler

2 Synchronize mechanical breathing with ineffective natural breathing if respiratory depression is present
3 Do not use positive pressure for expiration Natural passive expiration is sufficient and satisfactory
4 Do not waste time adjusting the collar if the patient is in serious condition Start respirator and adjust collar later Slight leaks do not render machine entirely ineffective

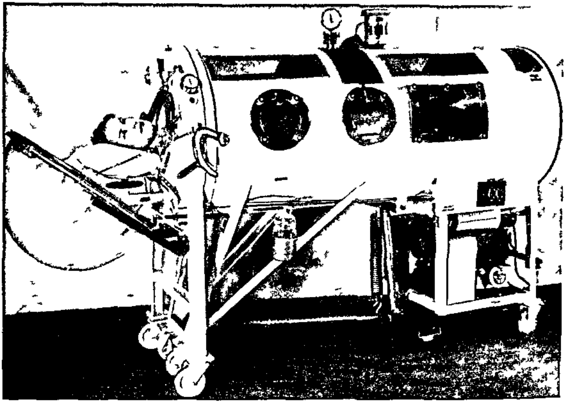

FIG 173 Iron lung (Tank respirator) The dome permits the use of intermittent positive pressure for insufflation for maintaining respiration when patient is out of tank (Courtesy J H Emerson Company)

5 Tilt body so that head is low if secretions are present Use pharyngeal suction if necessary
6 Operate apparatus at the lowest possible speed required to maintain effective respiration and circulation

REFERENCES

Drinker, P, and Shaw, L A An Apparatus for Prolonged Administration of Artificial Respiration J Clin Investigation, *7* 229, 1929
Schmidt, G F, and Seldon T H Practical Management of Patients in the Respirator Proc Staff Meeting Mayo Clinic *16* 456 July, 1941

AUTOMATIC MECHANICAL INSUFFLATORS

A number of different designs are available They derive energy from cylinders of compressed oxygen and inflate the lungs by an intermittent stream of oxygen The high pressure also operates a suction mechanism used

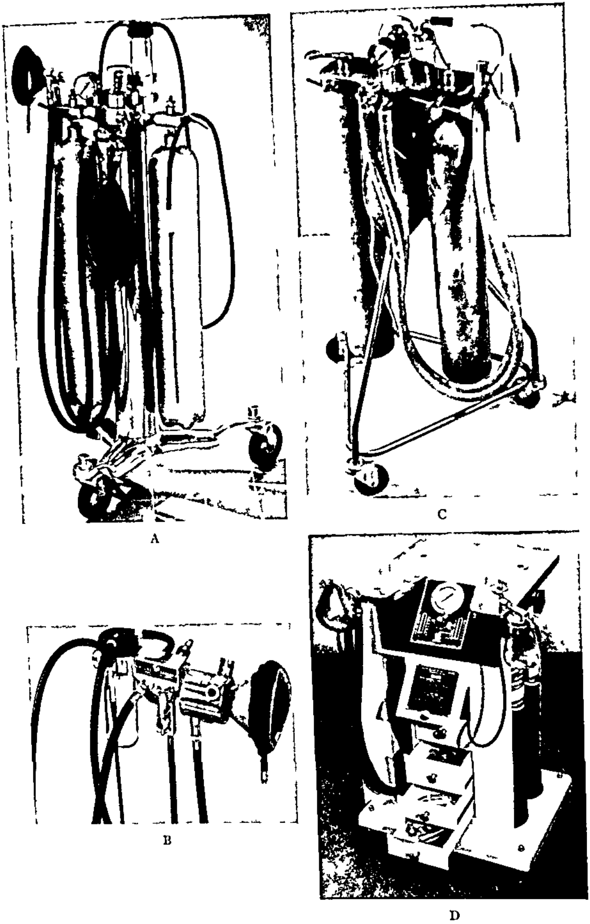

Fig 176 Positive negative ('blow and suck) respirators A E & J which operates from ordinary oxygen cylinders B Portable E & J model which operates from oxygen piping system C Emerson D Stephenson

3 Turn oxygen control valve until gas is heard to flow
4 Apply mask snugly to face using right hand and extend chin to support airway
5 Adjust gas flow to desired respiratory rate

Comment

1 A series of rapid clicks indicates obstruction of respiratory passages Adjust airway
2 Remember the respiratory rate depends upon volume flow The larger

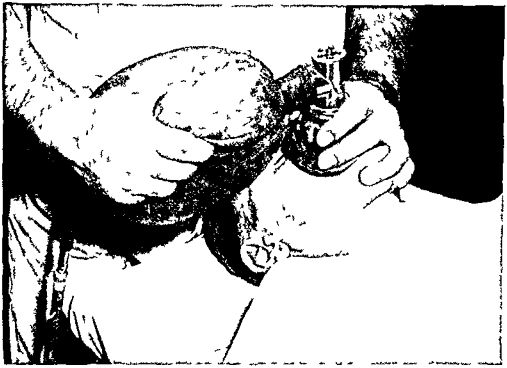

FIG 175 Use of To and Fro inhaler for artificial respiration Insufflation is accomplished by intermittently compressing the breathing bag Expiration is passive (Courtesy Meyer Saklad Inhalation Therapy and Resuscitation Springfield Thomas 1953)

the patient's tidal exchange the slower the rate which the machine delivers For large subjects the rate cannot exceed a fixed limit
3 A flow of gas but absence of respiratory movements indicates improper application of mask
4 Mask is held and airway maintained in same manner described for inhalation anesthesia
5 May fail to operate in face of slight respiratory obstruction which requires pressure greater than calibrated pressure to be overcome

Kreiselman Resuscitator

Description A simple apparatus, uses air or oxygen when available, composed of an accordian type bellows and mask Valves permit escape of exhaled

3 Inexpensive
4 Mechanical difficulties easily detected and corrected
5 Allows gradation of pressure up to 25 cms H_2O
6 Excess pressure not possible Is provided with safety escape valve to prevent rupture of lungs

Disadvantages

1 Prolonged use may interfere with venous return to heart
2 Air may be pushed into stomach if respiratory obstruction is present

Manual Insufflation

Definition The establishment of respiratory movements by insufflating oxygen into the alveoli by alternately compressing and releasing the breathing bag (Fig 174, 175)

Apparatus Any inhaler used for anesthesia composed of a mask, bag and canister and oxygen supply may be employed The to and fro or circle filter inhaler is satisfactory and this is the equipment usually employed

Principle

1 *Inspiration* This is obtained by manually compressing the breathing bag filled with oxygen and forcing the gas into the alveoli
2 *Expiration* This is obtained by recoil of chest wall and elastic tissue of lungs when the pressure is reduced by releasing the bag
3 *Oxygen Tension* Concentrations as great as 100% may be used
4 *Carbon Dioxide Tension* Slight or none

Procedure

1 Place patient in the supine position
2 Insert a pharyngeal airway or, if available, an intra tracheal airway
3 Apply mask to face and secure a snug fit Hold mask tightly to the face
4 Fill the breathing bag with pure oxygen Compress the bag rhythmically 12–18 times per minute to inflate the thorax
5 Release the pressure The bag inflates as the thorax deflates
6 Repeat this maneuver 12–18 times per minute Replace oxygen which leaks out

Advantages

1 It is instantly available in the operating room during surgery
2 Expiration is not accomplished by negative pressure but by the elastic recoil of the lungs
3 Insufflation pressure, rate of manipulation and oxygen tensions may be graded according to needs of patient and the wishes of the operator
4 It may be used over long periods of time

gases to outside atmosphere while bellows is being loaded with fresh gas (Fig 177)

Principle

1 *Inspiration* This is obtained by manually compressing the breathing bag filled with oxygen and forcing the gas into the alveoli
2 *Expiration* This is obtained by recoil of chest wall and elastic tissue of lungs when pressure is reduced by extending the bellows Exhaled air escapes at side
3 *Oxygen tension* Air is used A nipple at the top permits attachment

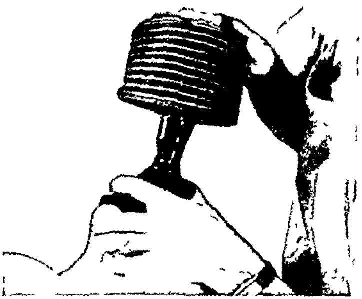

Fig 177 Bellows type of insufflator devised by Dr Joseph Kreiselman Inspiration is actively performed by graded amounts of positive pressure Expiration is passive and due entirely to the elastic recoil of the lungs without suction because an outlet valve opens to allow exhalations to escape while bellows are being extended Air is used but a nipple attachment for oxygen is provided

to hose from ordinary oxygen regulator at 4–5 liters per minute to enrich the mixture
4 *Carbon dioxide tension* Only that which is in air in mask

Procedure

1 Position of patient, insertion of airway, holding mask and rate of manipulation are as described above for insufflation technique
2 Insufflate lungs by compressing the bellows downward and allow lungs to deflate while replenishing

Advantages

1 Simple and instantly readied for use
2 Easily demonstrated to novices

SUMMARY

1 The arm lift back pressure method is the accepted method for general purposes, particularly in urgent cases when apparatus is not available
2 The "Drinker Respirator" is the most desirable for protracted periods of artificial respiration
3 Insufflation with the inhaler of the anesthesia apparatus is the most desirable and convenient for anesthesia and surgery

Remember

1 Initiate artificial respiration immediately Order assistants to carry out treatments or diagnostic procedures or ask a particularly competent assistant to maintain artificial respiration while the operator attends to other details
2 Maintain a patent airway The object of the manipulation is to remove carbon dioxide from alveoli and introduce oxygen in to them
3 Be gentle, slow, and deliberate in manipulations Gradual and rhythmic movements are the most desirable and effective
   a If manipulations are executed too quickly, carbon dioxide will be removed by hyperventilation and the apnea may continue from the resulting acarbia
   b If movements are too forceful, alveoli may be overdistended and apnea may result from stimulation of the Hering-Breur reflex
   c If insufflation is forceful, it may rupture the alveoli
   d If movements are too slow, inadequate ventilation results
4 Always use pure oxygen whenever available Air is satisfactory if no oxygen is available
5 After artificial respiration has been instituted, supply
   a Warmth
   b Fluids, if necessary
   c Analeptic drugs and other treatments as desired
6 Although the muscles of patients suffering from acute anoxemia may be spastic in the early phase, they are relaxed after prolonged asphyxia and do not have same resilience as normal tissues
7 Do not add carbon dioxide to the oxygen mixture The use of carbon dioxide for respiratory failure is a controversial subject Do not worry if it is not available Oxygen is the gas which must be *introduced into* the alveoli
8 Do not be too generous in the use of analeptic drugs Patients may recover unexpectedly and develop convulsions, or depression may follow stimulation by the drug
9 Always remain with a patient being treated with a *mechanical* device for maintaining artificial respiration until effective natural breathing is restored
10 When a protracted period of artificial respiration is required and the use of a mechanical method is contemplated, maintain the manual

Disadvantages

1 The insufflation pressure, if excessive, may rupture the alveoli
2 Gases other than oxygen may be erroneously employed (when anesthesia machines are used)
3 The thoracic negative pressure necessary to facilitate the venous return to the heart is not maintained and circulatory disturbances may follow
4 Oxygen is often forced into the gastrointestinal tract

Comment

1 Be positive the airway is free at all times and that the thorax expands and recoils easily
2 Use pure oxygen for insufflation
3 Discard the mixture and fill the bag with pure oxygen at frequent intervals when treating overdosage of volatile drugs
4 Connect the intra tracheal catheters if they are used to the inhaler with slip joints
5 Attach a manometer to the inhaler and do not exceed 20 cms water pressure when inflating the thorax of infants and children

REFERENCES

Waters, R M Artificial Respiration by Means of Intermittent High Pressure Inflation of the Chest with Oxygen Anesth & Analg *15* p 10, October, 1921
Saklad, M Inhalation Therapy and Resuscitation Charles C Thomas, Springfield, Ill, 1953

DISADVANTAGES OF MECHANICAL DEVICES

1 The machines are not always instantly available
2 Their use requires knowledge and skill for proper management
3 They do not necessarily employ sound physiological principles for ventilation of lungs
4 They are subject to mechanical defects and uncertainty in proper function of automatic adjustments
5 The negative pressure which some utilize for deflation is unnecessary and may predispose to pulmonary edema if used over long periods of time
6 They may inflate the gastro intestinal tract and cause trauma to vital organs
7 They may develop leaks in masks and other parts which render the apparatus ineffective
8 They are difficult to synchronize with natural but shallow ineffective breathing in instances in which respiration is depressed but has not failed

2 *Circulatory Failure*

a Cardiac arrest Cardiac massage, and intracardiac injection of epinephrine

b Peripheral circulatory failure (primary) Vasopressor drugs

c Peripheral circulatory failure (secondary) Fluids and cortical extract or cortisone

3 *Overdosage of Depressant Drugs*

a Inhalation anesthesia Metrazol as described under respiratory failure

b Barbiturate overdosage Picrotoxin for massive overdosage Metrazol for ultra short acting barbiturates

c. Other non volatile drugs Metrazol or coramine

Objection to Analeptic Drugs

1 They stimulate cells of the nervous system in the face of acute oxygen lack

2 They produce depression after the initial stimulation The depression may persist after the "emergency" is over

3 The period of stimulation may persist after the disturbance is relieved resulting in elevated blood pressure, convulsions, and hyperpnea

4 They antagonize the narcotic action of depressant drugs, but do not hasten the destruction of the drug The summation of the depression (which follows the stimulation) with the action of the narcotic produces even a greater depression

MANAGEMENT OF COMA DUE TO DEPRESSANT DRUGS (NON-VOLATILE)

The manifestations of overdosage of sedative drugs are loss of reflexes, respiratory depression, coma, and, in certain instances, circulatory depression The following measures should be instituted for all cases of drug poisoning of this type

1 *Institute Adequate Ventilation*

a Provide a satisfactory airway Support the chin, introduce a pharyngeal airway or intubate the patient, if necessary, to obtain unimpeded ventilation

b Augment respiratory movements, if they are inadequate, with artificial respiration Insufflation with inhaler of the anesthesia apparatus is satisfactory for short periods Place patient in Drinker respirator for protracted periods of respiratory failure

c Oxygen (100%) by nasal catheter or mask

2 *Remove Drug from Stomach*

a Introduce a stomach tube through the nose, aspirate the entire

method until the apparatus is available and the transfer can be accomplished without interruption of ventilation

11 *Do not hesitate to perform a tracheotomy in irremediable obstruction* of the upper respiratory tract *One more often regrets not having done a tracheotomy than having done one*

ANALEPTIC DRUGS

Definition An analeptic drug is a stimulating drug used as a restorative for depressed respiratory and circulatory mechanisms

Available Drugs The following drugs are the currently employed respiratory stimulants

- Metrazol
- Coramine
- Picrotoxin
- Nalorphine (Nalline)
- Carbon Dioxide

These drugs are the currently employed circulatory stimulants

- Epinephrine, ephedrine, and related amines
- Adrenal cortical hormone

Mode of Action Analeptic drugs exert their action by one or a combination of several of the following mechanisms

1 By stimulation of medullary and other vital centers Metrazol, coramine, picrotoxin, and carbon dioxide act in this manner
2 By stimulation of the carotid body, which, in turn, reflexly stimulates the respiratory center Lobeline, coramine, and cyanide derivatives act in this manner
3 By stimulation of sympathetic receptors in the arterioles to elevate blood pressure and improve general and cerebral circulation Epinephrine, ephedrine, and other sympathomimetic drugs act in this manner
4 By stimulation of the smooth muscle of the blood vessels to elevate blood pressure and improve general and cerebral circulation Pitressin, pituitrin, and ephedrine act in this manner
5 By stimulating the heart muscle and improving the cardiac output Digitalis (perhaps some of the above act in this manner)
6 By influencing capillary permeability and preventing fluid loss Adrenal cortical hormone acts in this manner

Uses

1 *Respiratory Failure* Administer metrazol 100 milligrams (10% solution) intravenously as the initial dose and repeat or coramine 250 milligrams (25% solution) intravenously Use these drugs as adjuncts to artificial respiration only

2 *Circulatory Failure*

a Cardiac arrest Cardiac massage, and intracardiac injection of epinephrine

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c Oxygen (100%) by nasal catheter or mask

2 *Remove Drug from Stomach*

a Introduce a stomach tube through the nose, aspirate the entire

contents, and send a specimen to the laboratory for immediate analysis

b Lavage the stomach with warm dilute sodium bicarbonate solution if drug is suspected of being acid (barbiturates) Use dilute vinegar if drug is alkaline, or potassium permanganate (¼%) if drug is an alkaloid

c Introduce saline cathartic into stomach through tube Do not use magnesium salts as they may further enhance the depression

3 *Support Circulation if Depression Is Present*

a Administer 1000 cc glucose in distilled water (5%) intravenously Fasten arm on board (particularly if the patient is restless)

b Administer plasma if hemocentration is present

c Administer a vasopressor substance, such as ephedrine or neosyn ephrine cautiously These are indicated when hypotension is present

4 *Promote Diuresis*

a Catheterize and measure the urinary output Send specimen to laboratory for analysis

b Administer glucose in distilled water (5%)

5 *Lavage the Colon with Physiological Saline Solution* This step is imperative, particularly if the drug is known to be excreted into colon (morphine)

6 *Administer an Analeptic Drug* to antagonize the depression The type depends upon the drug causing the depression Metrazol, coramine, or picrotoxin are the most commonly employed (see analeptics)

7 *Institute General Nursing Care*

Comment	*Reasons*
1 Remove secretions by suction if they appear Atropine gr 1/150 may be employed	Secretions become inspissated and obstruct airway
2 Chart intake and output of all fluids administered	Pulmonary edema may result if an excess of fluid (over 3500 cc in 24 hours) is administered
3 Turn patient from one side to his back to other side at least every hour	This procedure may assist in pre vention of bronchopneumonia which frequently complicates these cases
4 Use antibiotics in long cases	Pulmonary infection may occur from hypoventilation

Treatment of Depression Due to Narcotics with Nalorphine (Nalline)

Uses To overcome depression due to opium alkaloids (morphine, codeine) their derivatives—dilaudid, heroin, dicodid, metapon and synthetic nar cotics, demerol (meperidine), dromoran, nisentil

Procedure

1 Administer 5 mgm nalorphine intravenously over period of 1/2 to 1 minute and note response
2 Allow several minutes to elapse and administer an additional 5 milligrams

Comment

1 If no response has occurred use no more drug Depression probably not due to narcotic
2 If response has occurred with first dose but not second, administer no additional drug
3 If second dose causes a response or augments response of first, administer additional 5 milligrams

Precautions

1 Large doses cause depression Do not exceed 15 mgm in ordinary circumstances
2 The drug is not suitable for ether, barbiturates, chloral, avertin and central nervous system depressants other than narcotics

Use of Picrotoxin for Overdosage of Barbiturate

1 Follow routine described above for management of coma
2 Administer picrotoxin intravenously as a constant infusion at the rate of one milligram each sixty seconds until a lightening of narcosis appears The following manifestations are significant
   a Stirring, opening the eyes, movement of hands and feet, etc
   b Return of reflexes such as laryngeal, pharyngeal, superficial skin
   c Increased amplitude of respiration
3 Repeat half the intravenous dose required to obtain this effect subcutaneously within 30 minutes and each succeeding 30 minutes if the patient continues in the restored level of depression

Comment	*Reasons*
1 Administer picrotoxin until the desired therapeutic effect is obtained	In severe depressions, large initial doses are required to rouse the subject (10 milligrams or more)
2 Observe the patient closely for twitchings of small muscles, retching, vomiting or convulsions Administer pentothal in event convulsions occur and decrease succeeding doses of picrotoxin	These are toxic manifestations of overdosage of picrotoxin, due to too rapid administration
3 Lengthen the time interval for	The barbiturate is being detoxi

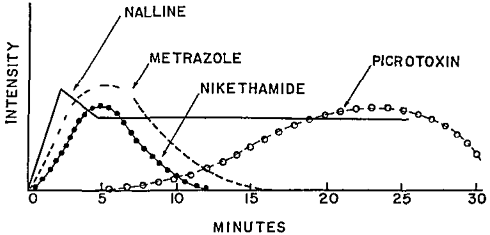

Fig 178 The relationship of onset and intensity of action to time manifested by metrazole nikethamide picrotoxin and N allyl nor morphine when used as analeptics during narcosis Note that the peak effect is reached within several minutes when metrazole is used Minute volume exchange is the criterion used to designate intensity of stimulation A latent period of 30 or more seconds precedes the onset of stimulation There is a gradual recession of respiratory activity after three or four minutes with a return to the pre injection state The latent period with ni kethamide is somewhat longer the peak of action is not quite as intense and the duration of action is briefer compared to metrazole Picrotoxin manifests a long latent period with a gradual rise in intensity to a plateau which may be sustained as long as 25 or 30 minutes The intensity is greatest with the substance The response depicted by these three drugs is by the intravenous route in a subject narcotized with barbiturate The N allyl nor morphine is used to reverse over dosage from morphine Note that the effect is sustained in contradistinction to the other analeptics

successive doses during the treatment to 45 minutes—or to one hour if signs of hyperirritability appear

fied by the tissues and the level of narcosis is being elevated because of the detoxification

4 Resort to intravenous injection of the picrotoxin in event the patient relapses into depression during the treatment

The subcutaneous dose may not always be sufficient to maintain the patient at the roused level

5 Remember that a latent period exists between the moment of injection and the onset of stimulation (Fig 178)

Overdosage may result if the drug is injected too rapidly because of this delayed effect

6 Remember that picrotoxin merely antagonizes the effect of the barbiturate and does not accelerate its destruction

Both picrotoxin and the barbiturate must be detoxified or eliminated from the body

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PART IX

INHALATION THERAPY

OXYGEN THERAPY

Definition The administration of oxygen enriched atmospheres by inhalation for therapeutic reasons

Purpose

1 To attempt to relieve anoxia by raising the alveolar oxygen tension
2 To increase oxygen in tissues above the normal concentration This is accomplished by increasing the dissolved gas by inhalation of nearly 100% oxygen
3 To facilitate the removal of gases, such as nitrogen or helium, from hollow viscera, body cavities, blood and other tissues

Methods of Administration

1 *By catheters* or inhalers placed in the nostril or nasopharynx This method is simplest and most practical for ordinary routine use
2 *By mask* This method is necessary to secure high alveolar concentrations of oxygen and for the successful desaturation of tissues of such gases as nitrogen or helium
3 *In a tent* or canopy equipped with a conditioner This method is suitable for children and patients who cannot tolerate masks or catheters
4 *In an oxygen room* This method is ideal but the least practical from economic standpoint

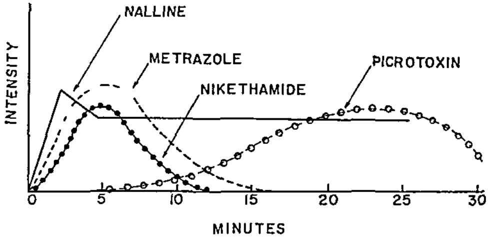
Source of Oxygen for Clinical Use

Use Oxygen is delivered to the bedside in one of 2 ways (1) In individual cylinders, (2) piped from a central source where it is stored in bulk Oxygen used for medicinal purposes has the following features

1 Is 99%–100% pure The contaminent is nitrogen
2 Is tasteless, colorless and odorless
3 Exists as a compressed gas in the cylinder at room temperature (not liquid)
4 Is made from liquid air
5 Differs in no way from chemically pure commercial oxygen
6 Is anhydrous

Features of Cylinders

1 Usually contain 244 cubic feet of gas expressed at room temperature and atmosphere pressure



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successive doses during the treatment to 45 minutes—or to one hour if signs of hyperirritability appear	fied by the tissues and the level of narcosis is being elevated because of the detoxification
4 Resort to intravenous injection of the picrotoxin in event the patient relapses into depression during the treatment	The subcutaneous dose may not always be sufficient to maintain the patient at the roused level
5 Remember that a latent period exists between the moment of injection and the onset of stimulation (Fig 178)	Overdosage may result if the drug is injected too rapidly because of this delayed effect
6 Remember that picrotoxin merely antagonizes the effect of the barbiturate and does not accelerate its destruction	Both picrotoxin and the barbiturate must be detoxified or eliminated from the body

REFERENCES

Adriani J Pharmacology of Anesthetic Drugs 3rd Ed Charles C Thomas Springfield Ill 1954

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Purpose

1 To attempt to relieve anoxia by raising the alveolar oxygen tension
2 To increase oxygen in tissues above the normal concentration This is accomplished by increasing the dissolved gas by inhalation of nearly 100% oxygen
3 To facilitate the removal of gases, such as nitrogen or helium, from hollow viscera, body cavities, blood and other tissues

Methods of Administration

1 *By catheters* or inhalers placed in the nostril or nasopharynx This method is simplest and most practical for ordinary routine use
2 *By mask* This method is necessary to secure high alveolar concentrations of oxygen and for the successful desaturation of tissues of such gases as nitrogen or helium
3 *In a tent* or canopy equipped with a conditioner This method is suitable for children and patients who cannot tolerate masks or catheters
4 *In an oxygen room* This method is ideal but the least practical from economic standpoint

Source of Oxygen for Clinical Use

Use Oxygen is delivered to the bedside in one of 2 ways (1) In individual cylinders (2) piped from a central source where it is stored in bulk Oxygen used for medicinal purposes has the following features

1 Is 99%–100% pure The contaminent is nitrogen
2 Is tasteless, colorless and odorless
3 Exists as a compressed gas in the cylinder at room temperature (not liquid)
4 Is made from liquid air
5 Differs in no way from chemically pure commercial oxygen
6 Is anhydrous

Features of Cylinders

1 Usually contain 244 cubic feet of gas expressed at room temperature and atmosphere pressure

2 Usually is at 2000 lbs per square inch
3 Are usually painted green
4 Are made of drawn steel
5 Have single valve protected by removable caps when not in use

OXYGEN THERAPY USING PIPING SYSTEM

Principle Oxygen in bulk is delivered to a central storage unit in the hospital and distributed to outlets located at the patient's bedside by a system of copper pipes

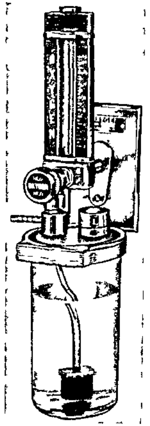

FIG 179 Wall unit consisting of humidifier and flowmeter (Courtesy National Cylinder Co)

Features

1 The gas is piped at a low pressure (60–100 lbs) from the high pressure (2000 lbs) storage unit
2 Only the flowmeter is required The pressure gauge is not necessary These are quickly detachable and replaceable to the wall unit (Fig 179)
3 Details of therapy after regulator is connected same as outlined for cylinder oxygen The wall unit takes the place of the cylinder and regulator described in the following procedures

Advantages

1 Reduces cost and labor
2 Eliminates cylinder handling and its inconveniences and hazards
3 Convenient and instantly available
4 Assures uninterrupted therapy

NASAL CATHETER TECHNIQUE

Principle The concentration of oxygen in the alveoli is raised by flowing pure oxygen through a nasopharyngeal catheter

Materials

1 One cylinder of oxygen The size usually employed contains 244 cu ft at 2200 lbs per square inch pressure
2 A suitable regulator consisting of a reducing valve, a flow meter calibrated in liters, a humidifier, and a pressure gauge (Fig 180)

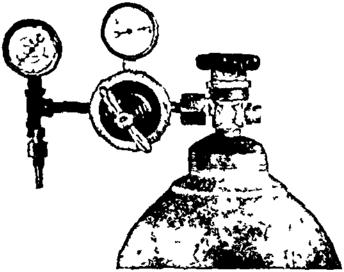

FIG 180 Assembly of regulator and pressure gauge for oxygen therapy A humidifing bottle is attached to the outlet when the catheter technique is employed (Courtesy of The Linde Air Products Company)

3 A catheter #12F which has four or five perforations at the tip (for children #10, or #8 in some cases)
4 A cotton or canvas wrapper or cover for the cylinder
5 A strap for securing the cylinder to the bed post
6 A cork or rubber mat 12″×12″ to place beneath the cylinder to protect floor
7 Adhesive cut in strips 4″ long×1/2″ wide
8 Petrolatum for lubricating the catheter
9 A rubber delivery tube from humidifier to catheter (5 feet long, 1/4″ inside diameter)

10 Stainless steel or plastic connector for catheter (5/16″×3″)
11 Wrench for tightening regulator

Procedure

1 Attach gauge and flowmeter to cylinder and tighten joints
2 Fill humidifier jar with water to designated line
3 Arrange cylinder on the mat at the right hand side of the head end of the bed Fasten securely with strap to the bed post

Fig 181 Administration of oxygen by nasal catheter (Courtesy of The Linde Air Products Company)

4 Explain the contemplated procedure to the patient
5 Mark off a distance on the catheter equivalent to the distance from tip of nose to the tragus of ear of the patient
6 Attach connecting rubber tubing to regulator and connect catheter to glass tip
7 Lubricate the catheter half its length from the tip with petrolatum
8 Commence the flow of oxygen at 5 liters per minute
9 Insert catheter as far as the designated mark gently into either nostril Use no force whatsoever in placing it The nostril through which the

catheter passes easiest and is most comfortable is the one to be selected

10 Immobilize the catheter over the forehead and bridge of the nose with several strips of adhesive so that it remains securely anchored (Fig 181)

Precautions

1 Always inspect the tubing leading from regulator to the catheter for perforations or kinks and be positive all of the oxygen is flowing to the patient
2 Be positive catheters are not kinked or obstructed by plugs of mucus in perforations
3 Be positive the catheter is not doubled upon itself in the nostril and that it is placed correctly in the nasopharynx (Fig 182)

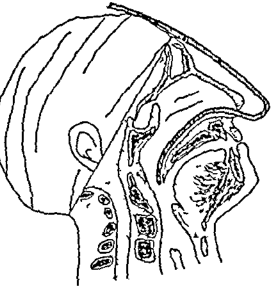

Fig 182 Correct placement of the catheter in the nasopharynx for oxygen therapy

Discontinuing Treatment

1 Loosen adhesive from head and nose and gently wiggle catheter Be certain that it is loose before withdrawing it from the nose
2 Turn off oxygen at regulator valve
3 Turn off main cylinder valve (turn anti clockwise)
4 Return all equipment to the supply room for cleaning and storing

Advantages of Catheter Technique

1 It is simple, easily installed, and serviced
2 It is relatively inexpensive
3 It is comfortable for the patient
4 It supplies a high tension of oxygen in the alveoli (approximately three times the normal alveolar oxygen tension)

10 Stainless steel or plastic connector for catheter (5/16″×3″)
11 Wrench for tightening regulator

Procedure

1 Attach gauge and flowmeter to cylinder and tighten joints
2 Fill humidifier jar with water to designated line
3 Arrange cylinder on the mat at the right hand side of the head end of the bed Fasten securely with strap to the bed post

FIG 181 Administration of oxygen by nasal catheter (Courtesy of The Linde Air Products Company)

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5 Mark off a distance on the catheter equivalent to the distance from tip of nose to the tragus of ear of the patient
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Waters, R. M., Buerki, R. C., and Hathaway, H. R. Oxygen Therapy at the Wisconsin General Hospital Hospitals, March, 1936
Wineland, A. J., and Waters, R. M. Oxygen Therapy Archives Surg., 22 67, 1930

Oxygen by the Mask Technique

Principle The alveolar oxygen concentration is raised by allowing the patient to breathe from a semi-open, semi-closed, or closed inhaler

Types of Inhalers

1. *Semi-open* The semi-open inhaler consists of loosely fitting celluloid, rubber, or plastic face pieces into which oxygen is conducted No valves or bags are employed (Fig 183)
2. *Semi closed* The semi closed inhaler designed for inhalation anesthesia may be employed for oxygen therapy The semi closed system is necessary for the administration of 100% oxygen and the desaturation of nitrogen from tissues Various simpler forms than those for anesthesia have been devised to be used for inhalation therapy The following are some of the most popular
   a. B.L.B This is composed of a mask, a rebreathing bag of one liter capacity and an exhalation valve composed of sponge rubber
   b. Barach Eckman This is composed of a bag, mask, and exhalation valve A calibrated injector is attached to the regulator for aspiration of air to dilute oxygen when concentrations less than 100% are desired Also known as the O E M mask
3. *Closed* The circle or to and fro inhaler designed for inhalation anesthesia may likewise be used to administer oxygen by the closed system

Note Follow the instructions provided by the manufacturer for each type of mask

REFERENCE

Barach, A. L., and Eckman, Morris A Mask Apparatus for High Oxygen Concentrations. J Aviation M March, 1941

B L B Mask Technique

Materials

1. Assemble the same material for the nasal catheter technique
2. Select the type mask desired
   Two types of masks are available *Oronasal and nasal* The nasal type is suitable for conscious subjects who can breathe through the nose Two sizes of B L B masks are available, a small and large

Procedure

1. Arrange the cylinder, flowmeter, tubing, etc., in the same manner described for the catheter technique

5 It does not interfere with the elimination of carbon dioxide
6 The catheter is tolerated and easily managed in comatose patients
7 It requires little care, once treatment is initiated
8 The flow of gas need not be discontinued during treatments, meals, or examinations

Disadvantages

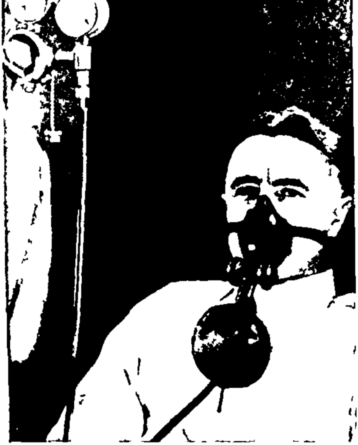
1 Uncooperative subjects do not always tolerate the catheter (children, delirious subjects)
2 It cannot be employed when high oxygen tension or when desaturation of other gases from tissues is desired

Comment

1 Be certain catheters are provided with several perforations This prevents the stream of gas from impinging on one area and irritating the mucous membranes
2 **Be sure the oxygen is humidified** The gas is anhydrous as it issues from the cylinder and irritates the mucous membranes
3 **Vary the flow of oxygen according to the needs of the patient** A flow of 5 liters per minute usually provides 35 to 40% oxygen in the inspired air Pulse and respiratory rate should be guide to efficiency of treatment
4 Do not insert the catheter beyond the measured distance into the pharynx If it rests in the oropharynx, oxygen is swallowed
5 Do not insert the catheter too short a distance into the nasopharynx The oxygen tension falls below 35% and the therapy is not satisfactory
6 **Do not fail to strap the cylinder to the bed post**
7 Do not use oil or grease to lubricate oxygen therapy equipment
8 Replace the catheter every 8 to 12 hours with a clean one
9 Maintain a record of the treatment upon a special form designed to indicate the following data
   a Date
   b Hour treatment was instituted
   c Temperature curve
   d Pulse rate
   e Respiratory rate
   f Color of skin
   g Flow of oxygen
   h Type of treatment

REFERENCES

Boothby, W M Oxygen Therapy J A M A , *99* 2026, 1932
Evans, J H Oxygen Therapy in Pneumonia Anesth & Analg , *6* 57, 1927
Waters, R M , and Buerki, R. C Oxygen Therapy at the Wisconsin General Hospital Hospitals, March, 1936



a

b

FIG 184 (a) B L B oronasal mask in use (b) Nasal B L B mask in use (Courtesy of The Linde Air Products Company)

a

b

Fig 183a and b Lombard face shield for oxygen therapy (Courtesy of The Linde Air Products Company)

4 Omit the humidifier if rebreathing is employed
5 Pass stomach tubes through the nipple provided for the purpose to insure a snug fit
6 Remove the plug at the end of the bag from time to time to drain off condensed vapor

FIG 185 Semi-closed mask for administering oxygen Rebreathing is minimized by an inspiratory valve at the neck of the bag and an expiratory valve at the top A calibrated resistance may be placed at the top at the exhalation port for expiratory positive pressure. The O E M mask operates on this principle (Courtesy Meyer Saklad Inhalation Therapy and Resuscitation Springfield Thomas, 1953)

BARACH ECKMAN METER MASK TECHNIQUE (O E M)

1 Assemble same material used for nasal catheter technique plus air injector
2 Semi closed mask with valves at inlet and outlet (Fig 185)

2 Connect the mask to the delivery tube in place of the catheter
3 Commence the oxygen flowing at approximately 8 liters per minute
4 Apply the mask so that it fits snugly to face Pack leaks with cotton to insure a comfortable and snug fit (Fig 184)
5 Fasten the head strap to maintain this fit
6 Readjust the flow of gas to suit the needs of the patient

Precautions

1 Be certain the mask fits properly and the flow of oxygen is sufficient to allow the rebreathing bag to remain inflated at all times
2 Restrain delirious patients
3 Be positive the exhalation valve is in satisfactory working order and that it allows the excess oxygen and carbon dioxide to escape without resistance

Discontinuing Treatment

1 Loosen the strap and remove the mask
2 Turn off oxygen at regulator valve and then at the main valve

Advantages of Mask

1 It allows the use of high oxygen tensions (100% if necessary)
2 It allows desaturation of tissues from other gases
3 It is portable and simple to service
4 It is inexpensive

Disadvantages

1 It allows some rebreathing Carbon dioxide may accumulate in the mask and bag if valves are not patent
2 The oxygen must be discontinued to administer medication and other treatments
3 The expiratory valve, particularly the sponge type, creates resistance to respiration
4 The mask is not comfortable and does not fit the face of all patients snugly

Comment

1 Remember that the B L B mask allows some rebreathing The first third of the expiration passes into the bag, the remainder passes through the sponge exhalation valve
2 Use a rapid flow of oxygen (7–10 liters per minute) to eliminate inspiratory resistance and to avoid carbon dioxide in the inspiratory air
3 Remember that the oxygen concentration is controlled by the flow of gas as follows 50–60%—4 liters per minute and allow bag to collapse 95–100%—8 liters and allow bag to remain distended

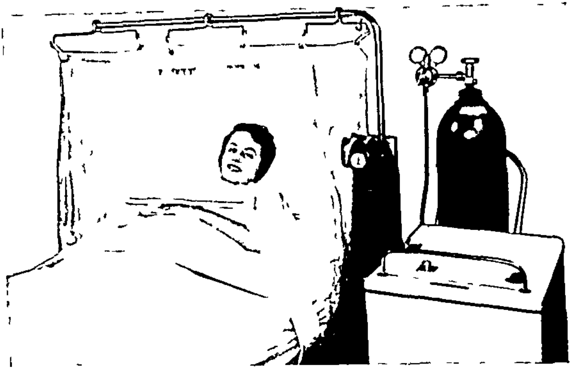


FIG 187 Oxygen tent of canopy type operated by mechanical refrigeration The mechanical unit recirculates the gases from the tent through the conditioning unit which removes moisture and carbon dioxide and cools the gas (Courtesy National Cylinder Company)

FIG 188 Oxygen tent cooled by flowing the gas through crushed ice Some recirculation is obtained by a jet utilizing the Venturi principle (Courtesy National Cylinder Company)

Procedure

1 Arrange cylinder, flowmeter, tubing in the same manner described for B L B technique
2 Attach mixing meter at outlet of regulator (instead of humidifier)
3 Adjust mixing valve to supply desired percentage of oxygen and air The figure indicates percent oxygen delivered
4 Turn on oxygen at rate sufficient to maintain a full bag

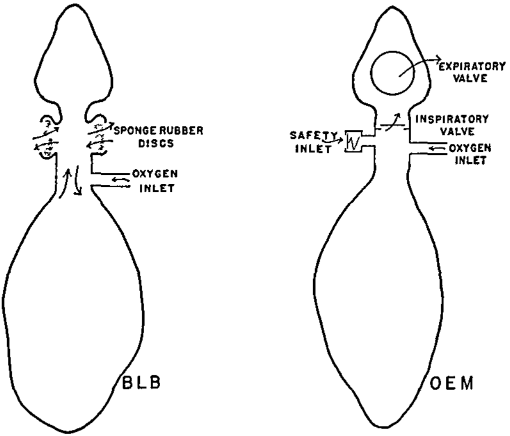


Fig 186 Schematic diagram of semi closed inhaler used for oxygen therapy (Courtesy Meyer Saklad)

Advantages

1 Eliminates rebreathing (except air in mask) (Fig 186)
2 Permits proportion of oxygen and air to be accurately fixed and maintained
3 Permits use of expiratory positive pressure to be applied
4 System is entirely semi closed

Disadvantages Same as those outlined for mask therapy with B L B

REFERENCE

Boothby, W M, Lovelace W R, and Bulbulian, A H Proc. Staff Meeting Mayo Clinic, *15* 194, 1940

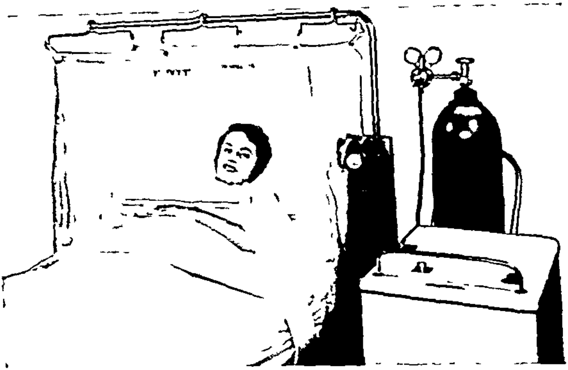


FIG 187 Oxygen tent of canopy type operated by mechanical refrigeration The mechanical unit recirculates the gases from the tent through the conditioning unit which removes moisture and carbon dioxide and cools the gas (Courtesy National Cylinder Company)

FIG 188 Oxygen tent cooled by flowing the gas through crushed ice Some recirculation is obtained by a jet utilizing the Venturi principle (Courtesy National Cylinder Company)

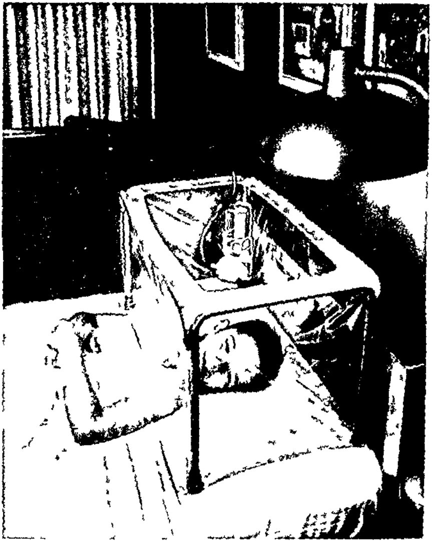


FIG 189 Open top tent with nebulizer for water and detergent (Alevaire) for fluidifying secretions The stream of oxygen is passed through the nebulizer creating a fine mist Antibiotics and other therapeutic agents may be administered by inhalation (Courtesy National Cylinder Company)

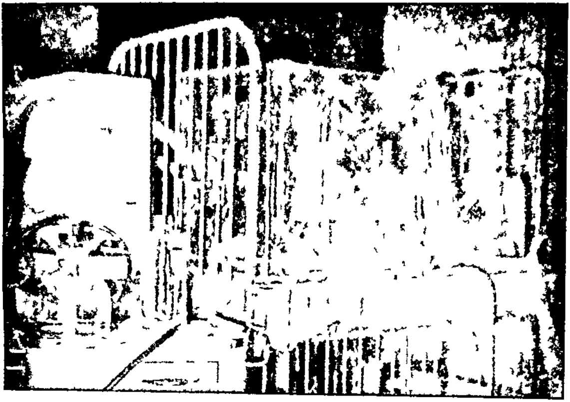
OXYGEN BY TENT

Definition of a Tent A tent consists of a gas proof canopy or hood which encloses the head or upper portion of the patient's body Connected to this canopy is a source of oxygen, a unit composed of a dehumidifier, a cooler, and a carbon dioxide absorber

Types Many types of tents are manufactured and available for clinical use These may be resolved into two types

1 Canopies which fit over the bed over the upper half of the patient's body (Fig 187)
2 Open box tent or canopies These are for infants and small children because the entire body is enclosed (Fig 191)

Procedure for Use of Tents Each type tent must be manipulated according



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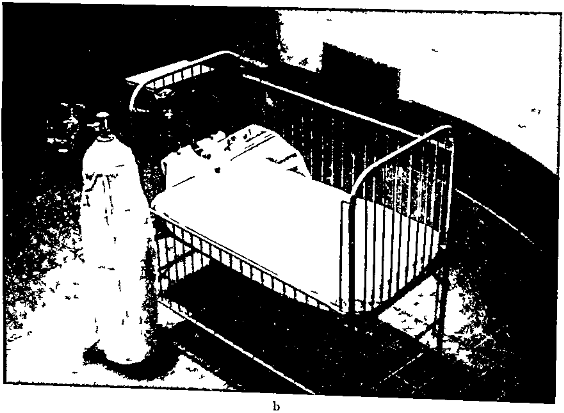

b

FIG 190 Oxygen tents for infants (a) Canopy type (b) Plastic hood Cooling is accomplished by using a jet utilizing the Venturi principle The gas is conducted through a coil surrounded by ice The box hangs over side of bed to eliminate the condensation of water on the patient and in the bed

to the instructions and recommendations of the manufacturer However, these general remarks apply to all tents

1 Analyze the concentration of oxygen at least every three hours
2 Watch the temperature and humidity in the tent closely Maintain at patient's comfort
3 *Increase the flow of oxygen temporarily each time the tent is opened* for treatments or examinations (15 liters for 15 minutes)
4 Inspect the canopy for leaks and see that skirts of the tent canopy are tucked in tightly beneath the bed covers
5 Use a rubber sheet over the mattress with the canopy type of tent

FIG 191 Open box tent permits ready access to patient for treatments and general care (Courtesy of The Linde Air Products Company)

Advantages of Tents

1 They allow a greater degree of comfort to the patient than catheters or masks They provide air conditioning in warm climates
2 They permit use of vaporized drugs

Disadvantages

1 The initial cost of the equipment prohibits its use in many institutions
2 They are more difficult to service than catheters or masks and require constant attention by trained attendants
3 The enclosure by the canopy psychically disturbs some patients
4 They are a fire hazard *Permit no smoking at any time in or around tents*
5 They interfere with treatments, medical examinations, and general care

REFERENCES

Barach, A L, A New Oxygen Tent J A M A, *87* 1213, 1926
Campbell J A A Box for the Administration of Oxygen Brit M J *1* 1245, 1936
Saklad M Inhalation Therapy Charles C Thomas Springfield Ill 1953

Making Rounds of Patients Receiving Inhalation Therapy

The inhalation therapist on duty should make rounds every three hours or as often as possible and do or note the following

1 Be certain that proper pressure exists in cylinders and flow of gases is adequate
2 Change all cylinders whose pressure is 100 lbs or less Such cylinders are near exhaustion
3 Remove and return equipment to the storage room on discontinued cases
4 Note whether or not the cylinder is properly placed on the mat and is securely fastened to the bed post
5 Note that the water is at proper water level in the humidifier bottle (3")
6 Note that no leaks exist in the line from the flowmeter to the catheter or mask
7 Note that catheter has not been displaced, kinked, or coated with inspissated mucus
8 Note that all masks are properly applied, leak proof, and in working order
9 Analyze the oxygen concentration in all tents every 3 hours
10 Observe that no smoking or other source of ignition is in the immediate vicinity of oxygen therapy apparatus
11 Change all catheters every 12 hours

Practical Hints

1 Maintain a record or chart for each patient Include the following items Date, hour, patient's temperature, pulse, respiration, color, type of treatment, duration
2 Open the cylinder valve slightly and then turn it on slowly at first when initiating a fresh cylinder
3 Store cylinders in a cool room away from all combustible materials
4 Mark used cylinders "empty" and arrange in an orderly fashion in a part of the store room away from full cylinders
5 Never attempt to administer oxygen or other compressed gases without a regulator
6 Transport cylinders on trucks designed for the purpose
7 Remove all oil and grease from the hands when handling cylinders
8 Always crack the cylinder valve (open slightly, and close quickly) to remove dust before applying the regulator
9 Never use any heating or electrical device in any oxygen tent
10 Commence treatment with an excess flow of oxygen and reduce according to respiration and pulse of patient

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1 Analyze the concentration of oxygen at least every three hours
2 Watch the temperature and humidity in the tent closely Maintain at patient's comfort
3 Increase the flow of oxygen temporarily each time the tent is opened for treatments or examinations (15 liters for 15 minutes)
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5 Use a rubber sheet over the mattress with the canopy type of tent

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Barach, A L A New Oxygen Tent J A M A 87 1213 1926
Campbell J A , A Box for the Administration of Oxygen Brit M J 1 1245, 1936
Sadlad M Inhalation Therapy Charles C Thomas Springfield Ill 1953

Procedure

1 Fill inhaler with oxygen and strap mask snugly to the face of the subject Turn on metabolic flow of oxygen
2 Close the soda lime absorber and allow patient to rebreathe his exhaled carbon dioxide until a hyperpnea is well established

TECHNIQUE USING PREFORMED MIXTURES

Materials

1 One cylinder of carbon dioxide (5%) oxygen (95%) mixture
2 A reducing valve, pressure gauge, and flowmeter
3 A semi closed inhaler consisting of rebreathing bag, mask, and exhalation valve

Procedure

1 Fill the bag of inhaler by closing the exhalation valve and obturator
2 Apply the mask to the face, open obturator and allow patient to breathe from filled inhaler
3 Allow gas to flow at the rate of 2 or 3 liters per minute, or fast enough to allow bag of inhaler to remain distended
4 Open exhalation valve sufficiently to allow the expired and excess gas to pass from the mask
5 Allow the hyperpnea to become well established

Note If pure carbon dioxide is available, the flowmeter of anesthesia apparatus may be used to form the desired mixture as follows 4 3/4 liters of oxygen to 250 cc of carbon dioxide for 95 5% mixture, or 4 1/2 liters to 500 cc for 90 10% mixture

Contra Indications to Inhalation of Carbon Dioxide

1 The presence of cardiac disease
2 The presence of hypertension
3 Dyspnea, hyperpnea, obstruction, and other types of respiratory difficulty
4 Acidosis from any cause
5 Emphysema, asthma, or pneumonia

HELIUM OXYGEN THERAPY

Definition Helium is an extremely light, inert inorganic gas It is the second lightest gas, also one of the least soluble gases known

Uses Mixtures of helium and oxygen are administered by inhalation to reduce the respiratory effort This is accomplished by one or a combination of the two following factors

11 Do not use water soluble lubricants for catheters as they dissolve in the nasal discharge
12 Always fasten the catheter over the bridge of the nose and over center of forehead for comfort and for correct placement of tip of catheter in nasopharynx

Cleaning Catheters and Inhalers

1 Scrub catheters with soap and warm water and rinse Remove adhesive with ether
2 Soak in bichloride of mercury 1 to 1000 for 30 minutes and rinse (do not use creosol or phenol)
3 Rinse, dry, and coat lightly with talcum if they are to be stored

Care of Masks

1 Wash with hot soap and water
2 Rinse with 70% alcohol and wipe with clean towel
3 Dry and powder with talcum to absorb moisture
4 Place in cool cabinet to prevent drying

CARBON DIOXIDE OXYGEN THERAPY

Purposes Inhalation of carbon dioxide in air or oxygen is employed for respiratory stimulation in the following conditions

1 Depressed states resulting from morphine, barbiturates or other drugs
2 To attempt to relieve persistent hiccoughs
3 To induce hyperventilation in the postoperative period to prevent respiratory complications by the forced expansion of the thorax
4 To hasten the dissociation of the carbon monoxide hemoglobin complex in carbon monoxide poisoning

Methods of Administration

1 By allowing a patient to rebreathe from a paper bag or a closed inhaler
2 By supplying a continuous flow of a preformed mixture to a semiclosed inhaler from a storage cylinder

Concentration Five per cent carbon dioxide in oxygen or air is usually employed

Technique by Rebreathing

Materials

1 The closed inhaler of an anesthesia machine
2 A cylinder of pure oxygen

Procedure

1 Arrange patient in comfortable position
2 Fill the breathing bag or inhaler with oxygen and apply mask to the patient's face so that a snug fit is secured
3 Open the exhalation valve, deflate rebreathing bag almost completely, and fill with oxygen helium mixture
4 Turn on oxygen at the rate of 500 cc per minute or in a quantity to satisfy the metabolic requirement of the patient
5 Allow patient to rebreathe the mixture for 3 to 5 minutes
6 Open exhalation valve, deflate bag and fill with oxygen helium mixture once again (this removes nitrogen)
7 Repeat several times after 3 or 4 minutes

Comment	*Reasons*
1 Eliminate nitrogen in the alveoli and inhaler by emptying the bag to obtain effective treatment	Nitrogen has a higher molecular weight than helium (7 times greater) It lacks the physical properties which render helium effective
2 Do not use pure helium for inhalation therapy	The gas is inert and causes asphyxia if oxygen is not added
3 Always supply oxygen when the rebreathing technique is employed	The oxygen in the mixture is gradually consumed by the tissues
4 Do not be alarmed if the patient's voice assumes a nasal tone	The speed of sound is decreased in the lighter medium and changes the quality of the voice

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Barach, A L Recent Advances in Oxygen and Helium Therapy Med Clinics North America, *24* 261, 1940

Lovelace W R Technique of Treatment With Helium and Oxygen Using B L B Inhalation Apparatus Proc Staff Meeting Mayo Clinic, *13* 786, 1938

Positive Pressure Oxygen Therapy

Methods

1 Continuous Positive pressure is applied during inspiration and expiration
2 Inspiratory Positive pressure is applied during the inspiratory phase of respiration Expiration is without resistance
3 Expiratory Positive pressure is applied during expiration Inspiration is unimpeded or unaided

Uses

1 For treatment of pulmonary edema

1 By decreasing the respiratory load (80% helium and 20% oxygen equals 1/3 the weight of an equivalent volume of air)
2 By increasing the rate of diffusion of the mixture The lightness of the helium molecule is responsible for this property
The mixture, therefore, appears to be of benefit to patients with dyspnea due to respiratory obstruction, bronchiolar constriction, stenosis of the trachea, etc

Methods of Administration Helium may be administered by

1 The semi-closed technique (B L B) The cost is prohibitive because a continuous flow is required
2 The closed system by the rebreathing technique The circle filter, the to and fro filter, or the hood type of tent (page 523) may be employed

Technique Using B L B Mask

Materials

1 A cylinder of pure oxygen (type G—220 cu ft)
2 A cylinder of helium oxygen mixture 80%–20% (type G)
3 One regulator for each type gas without humidifier
4 One Y connecting piece to fit connecting tube
5 One section of delivery tube 4 feet long, 1/4″ inside diameter
6 B L B mask—oronasal or nasal
7 Two sections of delivery tubes 18″ long

Procedure

1 Connect one short section of delivery tubing to the regulator on the oxygen cylinder, the other to the regulator on the helium cylinder
2 Connect the long tubing to the mask and to the stem of the Y piece
3 Connect the Y to the oxygen and helium
4 Allow the helium mixture to flow into inhaler so that the rebreathing bag is not quite emptied with each inspiration
5 Pad the mask well to occlude all leaks Decrease the flow of helium-oxygen mixture and gradually turn on pure oxygen until the patient is able to tolerate 100% oxygen
6 Continue the flow of gas mixture until the symptoms disappear

Techniques Using Closed Inhalers

Materials

1 A circle filter or a to and fro inhaler equipped with an exhalation valve
2 One cylinder of pure oxygen
3 One cylinder of helium-oxygen mixture (80%–20% or 75%–25%)
4 Flowmeter with yokes for oxygen, and helium oxygen mixture

Materials

1 Standard oxygen therapy regulator and humidifier
2 Ethyl alcohol—95%
3 Semi closed inhaler or oronasal catheter set up used for oxygen therapy

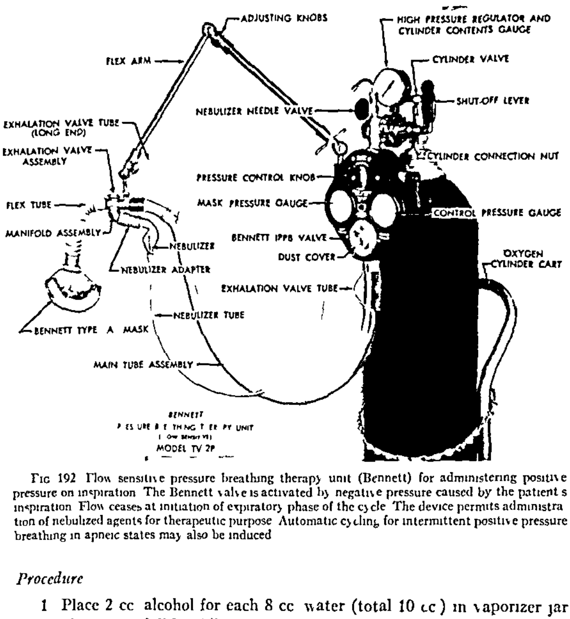

FIG 192 Flow sensitive pressure breathing therapy unit (Bennett) for administering positive pressure on inspiration The Bennett valve is activated by negative pressure caused by the patient s inspiration Flow ceases at initiation of expiratory phase of the cycle The device permits administration of nebulized agents for therapeutic purpose Automatic cycling for intermittent positive pressure breathing in apneic states may also be induced

Procedure

1 Place 2 cc alcohol for each 8 cc water (total 10 cc) in vaporizer jar almost to "full level "
2 Commence flow of oxygen at 5 liters into semi closed inhaler (O E M or B L B mask) or lubricated catheter placed into oropharynx
3 Continue treatment for 5 minutes If there is no sign of improvement increase alcohol adding 2 cc additional for each 8 cc of water originally used If still additional alcohol is needed add 2 cc more for each 8 cc water used

2 For treatment of obstructive dyspnea
3 For treatment of emphysematous states

Continuous Positive Pressure

Material

1 Closed inhaler To and fro or circle filter used for anesthesia equipped with water or aneroid manometer
2 Oxygen supply

Procedure

1 Fill inhaler with oxygen and distend bag to 8–10 cms H O pressure
2 Adjust flow into inhaler to maintain desired pressure on inspiration and expiration (10–4 cms H O)

Caution Prolonged use has deleterious effects on the circulation

Positive Pressure on Inspiration

Material Inhaler with demand valve activated by negative pressure (flow sensitive type of Bennett, Fig 192)

1 Select proper size mask
2 Open the oxygen supply by turning shut off lever down
3 Set control pressure gauge to read desired pressure
4 Apply mask and ask patient to breathe in normal manner
5 Adjust pressure to patient's comfort

Positive Pressure on Expiration

A *Using Semi closed inhaler with expiratory resistance (Barach Eckman, O E M mask)*

Procedure Adjust mask in same manner outlined for ordinary oxygen therapy and set resistance on expiratory valve at desired pressure (4 cms)

B *Using Anesthesia Apparatus*

Material

1 Closed to and fro or circle inhaler
2 Water manometer (Fig 14) or calibrated expiratory valve

Procedure Allow gas to flow into inhaler at rate to maintain a zero pressure at inspiration and to allow excess to escape through valve or the stem of the water manometer at desired positive pressure on expiration (4 cms)

Ethyl Alcohol Inhalations

Description Inhalation of vaporized ethyl alcohol as an anti foaming agent

Uses For the treatment of pulmonary edema

Materials

1 Standard oxygen therapy regulator and humidifier
2 Ethyl alcohol—95%
3 Semi closed inhaler or oronasal catheter set up used for oxygen therapy

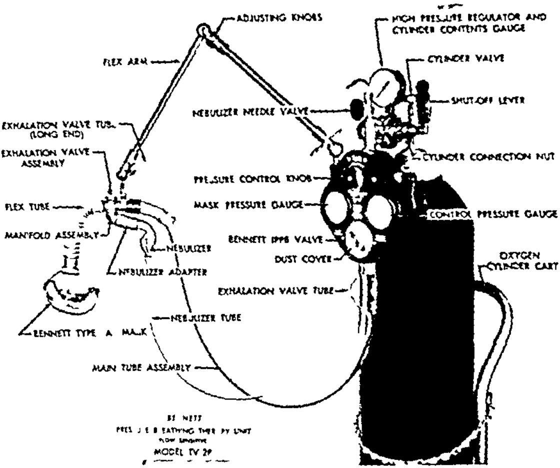

FIG 192 Flow sensitive pressure breathing therapy unit (Bennett) for administering positive pressure on inspiration The Bennett valve is activated by negative pressure caused by the patient s inspiration Flow ceases at initiation of expiratory phase of the cycle The device permits administration of nebulized agents for therapeutic purpose Automatic cycling for intermittent positive pressure breathing in apneic states may also be induced

Procedure

1 Place 2 cc alcohol for each 8 cc water (total 10 cc) in vaporizer jar almost to ' full level "
2 Commence flow of oxygen at 5 liters into semi closed inhaler (O E M or B L B mask) or lubricated catheter placed into oropharynx
3 Continue treatment for 5 minutes If there is no sign of improvement increase alcohol adding 2 cc additional for each 8 cc of water originally used If still additional alcohol is needed add 2 cc more for each 8 cc water used

Precautions

1 The mixture is highly inflammable
2 Do not leave alcohol in apparatus after use
3 Do not smear alcohol on regulator—it may pass into the device and cause a flash fire or an explosion
4 Do not nebulize alcohol in tents, or hoods Explosions may result

Comment

1 Ethyl hexanol may be used with same effect instead of alcohol to reduce fire hazard
2 Do not use more than a total of 6 cc of alcohol for each 8 cc water

Fig 193 The O E M mask being used for expiratory positive pressure The resistance on the valve is calibrated to 4 cms H_2O pressure (Courtesy Meyer Saklad, Inhalation Therapy and Resuscitation Springfield Thomas 1953)

Analyzing for Oxygen Using Beckman Analyzer

Description The Beckman oxygen analyzer employs the Pauling principle which takes advantage of the fact that oxygen is paramagnetic and affects the lines of force in a magnetic field (Fig 194)

Uses

1 Place free end of rubber tube which connects with sampling bulb at point from which sample is to be taken

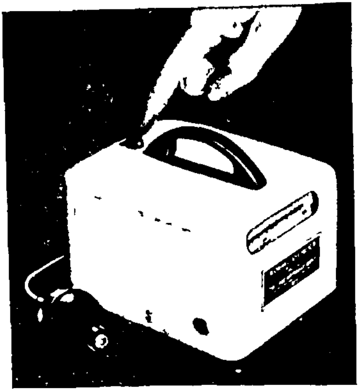

Fig 194 Oxygen analyzer (Beckman) based upon the principle that oxygen is paramagnetic (Courtesy Meyer Saklad Inhalation Therapy and Resuscitation Springfield Thomas 1953)

2 Slowly squeeze and release aspirator bulb 4 or 5 times to insure complete removal of previous sample and take in new sample
3 Press light with switch on top of instrument
4 Read oxygen concentration on top of scale

Comment

1 Glass tube on back containing silica absorbs moisture so that dry gases are led into apparatus
2 Readings are affected by temperature Device should be used in temperature range between 65 and 85°F
3 Failure to obtain image on scale is due to
   a Burned out lamp in apparatus
   b Exhausted dry cells
   c Quartz string which suspends mirror inside is broken
4 Pink color in quartz indicates drying power is gone May be regenerated to blue by heating to 300°F

APPENDIX

TABLE I (APPENDIX)

Urine Analysis

Volume in 24 hours	750-2 000 cc
pH	4 8-7 5
Specific Gravity	1 015-1 020
Total Nitrogen	12-18 gm in 24 hrs
Urea Nitrogen	10-40 gm in 24 hrs
Creatinine	1,000-1 500 mgm 24 hrs
Ammonia Nitrogen	*600 mgm in 24 hrs*
Uric Acid	400-1,000 mgm 24 hrs
Chloride (as Sodium Chloride)	10-15 gm in 24 hrs
Phosphates	1-2 gm in 24 hrs
Sulfates	1 5-3 5 gm in 24 hrs
Urobilinogen (Watson)	0-4 0 mgm
Urinary Diastase (Amylase)	*8-32 units*
17 ketosteroids	12-15 mgm in 24 hr

Kidney Function

Phenosulfonephthalein test	*75%* excretion of dye in *2 hrs.*
Urea clearance	75 130%

Blood Chemistry

Constituent	*Test Material*	*mgm /100 cc*
Total solids	whole blood	10 23
Total protein	plasma	6 5-8 2
Albumin	plasma	3 8-6 7
Globulin	plasma	1 2-3 5
Fibrinogen	plasma	0 3-0 6
Total nitrogen	whole blood	3 0-3 7
Non protein nitrogen	whole blood	25-35
Ammonia nitrogen	whole blood	0 1-0 2
Undetermined nitrogen	whole blood	4-18
Hemoglobin		
(men)	whole blood	14-17 (gms per 100 cc)
(women)	whole blood	13-16 (gms per 100 cc)
Glucose	whole blood	80-120
Total Lipoids	plasma	450-550
Total Fatty Acids	plasma	190-450
Neutral Fat	plasma	0-370
Cholesterol	plasma	130-230
Lecithin (Phospholipids)	plasma	60-350
Bilirubin	serum	0 1-0 8
Chlorides (as Sodium Chloride)	whole blood	450-500
Chlorides (as Sodium Chloride)	plasma	570-620
Sulfates (inorganic as S)	whole blood	1 04±0 05
Phosphorus inorganic	plasma	570-620
Calcium	serum	9 3-11 0
Magnesium	serum	1-3
Sodium	serum	330
	whole blood	310-345
Potassium	serum	16-22
Diastase (Amylase)	plasma or serum	80-150 units (Somogyi)
Vitamin C (Ascorbic acid)	plasma	0 8-2 4
Iodine (Protein bound)	serum	3 5-8 5 gamma
Lipase	plasma or serum	Less than 1 5 cc of N/20 NaOH
Alkaline Phosphatase Adult	serum	1 5-4 0 Bodansky units
Alkaline Phosphatase Children	serum	5-12 Bodansky units
CO combining Power	plasma	50 80 vol per cent
Hydrogen ion conc	whole blood serum	pH 7 4
	serum	pH 7 6-7 9

TABLE I (APPENDIX)—*(continued)*

Cerebrospinal Fluid

Amount	60 150 cc
Specific Gravity	1 001–1 010
Reaction	alkaline
Total solids	0 8–1 2 gm /100 cc
Calcium	2 5 11 2 mgm /100 cc
Chlorides	740 mgm /100 cc
Sugar	45 85 mgm /100 cc
Total protein	15–40 mgm /100 cc

Liver Function Tests

	Normal Values
Serum Bilirubin less than	1 0 mgm /100 of serum
Cephalin-cholesterol Flocculation (Hanger) less than	4 units
Urobilinogen in urine less than (Watson)	1 2 Ehrlich units
Bromsulphalein Excretion	No retention of dye after 45 min
Icterus Index (Bilirubin content)	4–6
Hippuric Acid Excretion	
Oral test	3 0 gm of Sodium Benzoate as Benzoic acid
Intravenous test	0 7 gm of Sodium Benzoate as Benzoic acid
Galactose Tolerance	Less than 3 0 gms of sugar excreted in 5 hr test period
Levulose Tolerance	Blood sugar not to rise above 130 mgm /100 cc of blood
Thymol Turbidity	0–4 units
Cholesterol—cholesterol ester ratio	60–90% of total cholesterol
Iso Iodeikon Test	10% retention in serum 1/2 hr
	5% or less retention in serum 1 hr
	(greater the retention the greater the impaired liver function)

Hematology

Coagulation time (Lee White)	5–8 minutes
Bleeding time	1–2 minutes
Contraction of clot	1–2 hours
Prothrombin time (Quick)	22–25 second
Prothrombin time	
(Shapiro)—whole blood	15 5 seconds ± 1 5
diluted blood	39 5 seconds ± 2 5
Erythrocyte Sedimentation Rate	
Westergren—men	1–5 mm /hr
women	2–10 mm /hr
Linzenmeier—men	350–600 minutes
women	300–600 minutes
Wintrobe—men	0–9 mm /hr
women	0–30 mm /hr

Cardiac Hemodynamics (Cardiac Catheterization)

Right auricular mean pressure	−2 to +3 mm Hg
Right ventricular pressure	25 systolic
	2 diastolic
	mean 13
Pulmonary artery	25/8 mean 15
Brachial artery	120/70 mean 90
Cardiac index (cc /min /m²)	3 1 ± 0 4
A V O_2 difference	4 2–4 7
Stroke volume—cc	80
O_2 consumption (cc /min /m²)	150
Peripheral resistance (dynes/sec /cm ²)	1138–1216

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Alkaline Phosphatase Children	serum	5–12 Bodansky units
CO_2 combining Power	plasma	50–80 vol per cent
Hydrogen ion conc.	whole blood serum	pH 7 4
	serum	*pH 7 6–7 9*

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TABLE II (APPENDIX)

Conversion Factors for Metric System

	Exact	*Approximate*
1 cubic centimeter	16 23 minims	15 minims
1 liter (1000 cc)	33 8 fl. oz	1 qt
1 milligram	0 0154 grain	1/60 gr
1 gram	15 423 grains	15 gr
1 grain	64 8 milligrams	60 mgm
1 dram	3 89 grams	4 gm or 4 cc.
1 ounce	28 35 grams	30 gm or 30 cc
1 millimeter	—	1/25 inch
1 inch	2 54 cm	2 5 cm
1 pint (16 oz)	475 00 cc.	500 cc

TABLE III (APPENDIX)

Temperature Conversion Factors

Fahrenheit to Centigrade—Subtract 32 from F ° reading and multiply by 5/9
Centigrade to Fahrenheit—Multiply C ° by 9/5 and add 32 to the result

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This Book

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By John Adriani, M D

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